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Open File Report 6168

Descriptions of Modelling and Coordinate System Conventions for the Integrated Three-Dimensional (3D) Deposit Modelling Project: Discover Abitibi Initiative

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ONTARIO GEOLOGICAL SURVEY

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Descriptions of Modelling and Coordinate System Conventions for the Integrated Three-Dimensional (3D) Deposit Modelling Project: Discover Abitibi Initiative

by

P.C. Thurston, L. Cotesta, C.A. Hawson and P. Vasak

2005

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A project of innovation, cooperation and revitalization

Découvrons l'Abitibi
Un projet d'innovation, de coopération et de renouvellement

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The Discover Abitibi Initiative is a regional, cluster economic development project based on geoscientific investigations of the western Abitibi greenstone belt. The initiative, centred on the Kirkland Lake and Timmins mining camps, will complete 19 projects developed and directed by the local stakeholders. FedNor, Northern Ontario Heritage Fund Corporation, municipalities and private sector investors have provided the funding for the initiative.

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Abstract

This report describes modelling procedures and data treatment standards for the Integrated 3D Geoscientific Deposit Modelling Project funded by Discover Abitibi Initiative. The models were produced to stimulate exploration and improve interpretation of structural and stratigraphic relationships in the Greenstone Architecture project. The goals of the project were 1) to provide three-dimensional (3D) models of 18 lode gold deposits and 2 volcanogenic massive sulphide deposits in the Ontario portion of the Abitibi greenstone belt; 2) to integrate the models with the surface geology; and 3) to review the resulting models for completeness and accuracy with the deposit owners and/or data donors.

The project received donations of 9 existing models from mine operators and produced 11 new models from mine plans and sections provided by property owners for a total of twenty 3D models. Benefits to the mining industry include stimulation of exploration through 3D visualization of relationships at both a property and a regional scale.

The project was produced by a research consortium consisting of the Mineral Exploration Research Centre (MERC) and the Mining Innovation, Rehabilitation and Applied Research Corporation (MIRARCO), both of Laurentian University, Sudbury, Ontario.

Data acquisition consisted of procurement of donated models and the scanning and/or copying of mine plans and sections for models built in-house. At this stage, we also acquired diamond-drill records to supplement information on the plans. Data preparation involved conversion of raster-style mine plans and sections to vector format through digitizing in AutoCAD™ or ArcGIS™, and conversion from local mine coordinates to UTM coordinates in NAD 83. A major part of data preparation involved reduction of complex drill-based datasets through compilation in Excel™ or Datamine™. At this stage, mine geological legends were compiled and translated to be consistent with the regional-scale legend of the Ontario Geological Survey (OGS). Data was then imported into either gOcad™ or Datamine™ for modelling.

Descriptions of Modelling and Coordinate System Conventions for the Integrated Three-Dimensional (3D) Deposit Modelling Project: Discover Abitibi Initiative

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Introduction

This report describes the modelling procedures and data treatment standards for the Integrated 3D Geoscientific Deposit Modelling Timmins and Kirkland Lake Region project funded under the Discover Abitibi Initiative. The Discover Abitibi Initiative was designed to "coordinate and direct an integrated geoscientific investigation of the Abitibi greenstone belt of northeastern Ontario" (www. Discover Abitibi.com). The Discover Abitibi Initiative aimed to stimulate the minerals industry by funding geophysical and geological projects to generate new exploration targets. This mission of the Discover Abitibi Initiative was accomplished by an integrated series of projects ranging from geophysical surveys, to investigation of the metallogenic architecture of the belt through various types of geological mapping and the 3D mineral deposit modelling project presented here.

The Integrated 3D Geoscientific Modelling project has 3 goals:

1) Produce digital and analog 3D models of 16 mineral deposits within the Abitibi greenstone belt

2) Integrate the models with the surface geology using both regional-scale maps and 1:10 000 scale maps or smaller

3) Provide a review of resulting models in Laurentian University's Virtual Reality Laboratory for
    - data donors (private, pre-publication sessions)
    - exploration industry as a whole
    - creation of digital and hard copy datasets for the exploration industry

The models were produced as an adjunct to the Discover Abitibi Greenstone Architecture project, to enable improved interpretation of the structural and stratigraphic setting of mineral deposits in the evolution of the greenstone belt. The benefits to mining and exploration companies of creating mineral deposit models, or the data with which to produce the mineral deposit models, are many:

- Creation of a 3D, georeferenced digital model of a deposit is particularly beneficial as three-dimensional relationships may well become apparent for the first time.
- Integration of 3D mineral deposit models at camp and regional scales allows better understanding of large-scale geological relationships.
- Examination of 3D mineral deposit models by geoscientists or investors from outside the company may provide new interpretive insights, in that individuals with differing experience are able to view and re-interpret the geological setting.
- The company donating the data may be able to obtain tax credits for the donation of the data.
- The 3D mineral deposit models may serve to increase the potential for investment in particular companies. This is in part because 3D geological relationships become more apparent and may reveal the presence of previously unsuspected mineralized zones, which may enhance the attractiveness of the property for investors.
- Data extraction and/or processing may lead to discovery of new orebodies for exploitation.
- A digital archive of historical data is created, which is of particular benefit to historical properties with data predating the digital age.
- Deposit models enhance the results of Discover Abitibi Greenstone Architecture project.

Overview of the Project

The Integrated 3D Deposit Modelling project was produced by a research consortium consisting of the Mineral Exploration Research Centre of Laurentian University (MERC) and the Mining Innovation, Rehabilitation and Applied Research Corporation of Laurentian University (MIRARCO).

MERC was the prime contractor with Discover Abitibi and provided the scientific foundation for the project. This foundation is developed from the knowledge, on a world scale, of the geology of Precambrian mineral deposits. In detail, the foundation includes the knowledge of the architecture of the two types of mineral deposits modelled in the project (lode gold deposits and volcanogenic massive sulphide (VMS) deposits); their constituent rock types; associated structures; and deposit, camp and regional lithological and structural patterns related to their distribution. MERC also provided expertise for review of deposit models developed in this project by specialists in lode gold and VMS deposits who were involved in research conducted under the Discover Abitibi Greenstone Architecture project.

MIRARCO provided technological expertise in data handling founded on several years' experience in mineral deposit modelling. This modelling experience includes experience in integrated geological modelling in both two and three dimensions. The project was enhanced by the use of the "Collaborative Immersive Virtual Reality" technique (CIVR) utilizing the Virtual Reality Laboratory, which enables viewing of three-dimensional images of the models during development and review by the data donors.

PROJECT TEAM

The project required assembly of a diversified team to handle the various aspects of the modelling process. Scientific direction of the project was provided by P.C. Thurston (MERC) while S. Maloney (MIRARCO) provided project management and direction of MIRARCO staff. L. Cotesta (MIRARCO) was the Data Interface Lead, responsible for acquisition of models and data from donor companies and data handling once materials were received. P. Vasak (MIRARCO) was the Deposit Model Creation Lead, responsible for leadership on model creation processes. A. Dasys was the Project IT Consultant. Document scanning and digitization was provided by BLAZE Information Technology Inc. (BLAZE I.T.).

The model creation process involved the entire team in the many diverse aspects of the project such as data verification, transformation of data from its original form to that required for modelling, refinement of the technical aspects of models (reduction of file size, etc.), to the creation of the various types of final products from the models produced. The individuals who contributed to the building of mineral deposit models are listed below in alphabetical order.

- R. Anderson
- L. Cotesta
- C.A. Hawson, P.Geo.
- F.D. Prévost
- L. Robertson
- A. van Wageningen
- P. Vasak, P.Eng.
- G. Wang
- J. Whitmore
- G. Yang

In the sections dealing with the models for individual deposits created by staff of MIRARCO, the lead modeller is identified.

MODELLING PROCESS

The fundamental objective of the project was to develop 3D georeferenced models of Abitibi greenstone belt ore deposits. This was accomplished by either importing existing digital models or creating new models. Existing models were imported for 6 deposits: Falconbridge Ltd. (Kidd Creek Mine); Porcupine Joint Venture (Dome, Pamour and South Tisdale Anticline mines); St Andrew Goldfields Ltd. (Clavos and Stock deposits). New models were created for 10 deposits: Newmont (Holt-McDermott and Holloway mines); Kirkland Lake Gold (Macassa, Kirkland Lake Minerals, Teck-Hughes, Wright-Hargreaves and Lakeshore mines); Queenston Mining Inc. (Upper Canada Mine, Anoki and McBean deposits); and Millstream Minerals (Potter Mine). Table 1 lists all deposits modelled in this project.

Table 1. Mineral deposits modelled in the Integrated 3D Mineral Deposit Modelling project.

Deposit	Donated Model	Model created from
VMS deposits		
Millstream Mines: Potter Mine	No	Mine plans and sections, drilling, and geophysical data
Falconbridge Ltd.: Kidd Creek Mine	Yes	gOcad™ model; donated by Falconbridge Ltd.
Lode Gold Deposits		
St Andrew Goldfields Ltd.: Stock deposit Clavos deposit	Yes	FracSIS™ model; donated by St Andrew Goldfields Ltd.
Porcupine Joint Venture: Dome Mine South Tisdale Anticline mines (4 deposits) Pamour Mine	Yes	Vulcan™ models; donated by Porcupine Joint Venture
Newmont Mining Corp.: Holloway Mine Holt-McDermott Mine	No	Promine™ digital data, mine plans, sections, drilling; donated by Newmont Mining Corporation
Kirkland Lake Gold Inc.: Macassa, Kirkland Minerals, Teck-Hughes, Lakeshore and Wright-Hargreaves	No	Datamine™ models of mine infrastructure and drilling; paper mine plans and sections; donated by Kirkland Lake Gold Inc., and sections from Thomson (1948) and Thomson et al. (1948)
Queenston Mining Inc.: Anoki, McBean and Upper Canada mines		Gemcom™ model of infrastructure and ore reserves for Anoki. AutoCAD™ drawings, paper mine plans and sections and drilling donated by Queenston Mining Inc., and Inco Ltd.

There were 2 additional deposits that were not included in the project as suitable data could not be obtained within the allotted timeframe. These deposits are the Taylor deposit of St Andrew Goldfields Ltd. and the Cheminis deposit of NFX.

In general, digital plans and sections from software such as AutoCAD™ or Datamine™ were brought into gOcad™ for modelling. Drill data was brought into Excel™ or Datamine in order to reduce the complexity of the drill logs for eventual inclusion into the various gOcad models. If polygons for such items as mine infrastructure were too complex, the file was treated with Poly Trans™, software that

reduces the complexity and number of polygons. A number of MIRARCO proprietary "plug-ins" were used for such tasks as coordinate rotations.

Analog plans and sections were scanned by personnel of BLAZE I.T. at the mine sites and then digitized in a CAD program or ArcGIS™, separating the linework and polygons at the digitizing stage into faults, lithological contacts, etc., as detailed in subsequent sections of this report. Data were brought from local mine coordinates into UTM coordinates using the NAD 83 datum when the mineral deposit model was brought into FracSIS™ for production of the final digital project.

The draft models were verified through on-screen reviews with domain experts, and then a Virtual Reality Laboratory (VRL) session with data donors and domain experts.

MODELLING AND DATA TREATMENT SOFTWARE[1]

Conversion of paper mine plans and sections to digital format was done by BLAZE I.T. using a 45-inch colour scanner. Data preparation, such as the simplification of drill-hole databases, was done in Datamine or Excel. Coordinate system transformation, such as rotation and translation from mine grid to UTM grid, was generally done in ArcGIS. Digitizing was done with a mix of AutoCAD and ArcGIS. Modelling by MIRARCO was done in gOcad 2.0.8 for most models, with one model at least in part produced in Datamine.

MODEL LIMITATIONS

Variability in Original Data

Data quality was immensely variable, with some plans and sections containing very little lithological or structural information. As mining progressed in some deposits, particular mineralized faults acquired at least informal names. However, it was reasonably common to have no designation of particular features on several levels of mine plans, leaving some degree of interpretation or uncertainty in interpretation when building the models. Shallowly dipping features are not visible on mine level plans and, for some deposits, the number of sections available was limited. A valuable source of sections, therefore, were those in the report of Thomson et al. (1948), which were used in producing the models for Kirkland Lake Gold Inc. Thomson's level plans (Thomson et al. 1948) were not built on a common grid. This resulted in the necessity for careful georeferencing of the level plans to enable correct positioning of the cross sections; however, because of scaling errors and paper folds, for example, the georeferencing to Ispolatov (2005) and Ispolatov and Lafrance (2005) is at best a close approximation.

The level of detail on mine plans varied immensely. The problem was exacerbated by the fact that in some of the larger mines, such as the Lakeshore Mine, there were two geological crews working on a daily basis and adopting differing conventions on the nomenclature for structures. Figures 1 and 2 illustrate the variability in levels of detail available.

Some deposits had immense internal variability in logging terminology, with individual units logged in a variety of ways. The familiar problem of gold-bearing quartz veins being logged as quartz veins, quartz stringers, brecciated quartz veins, etc., caused much difficulty in generalizing drill logs.

[1] Reference to a number of proprietary software programs are found throughout this report. For ease of reading, the trademark symbol has been used at first mention of the software name, but thereafter the software is identified by the owning company's capitalization conventions.

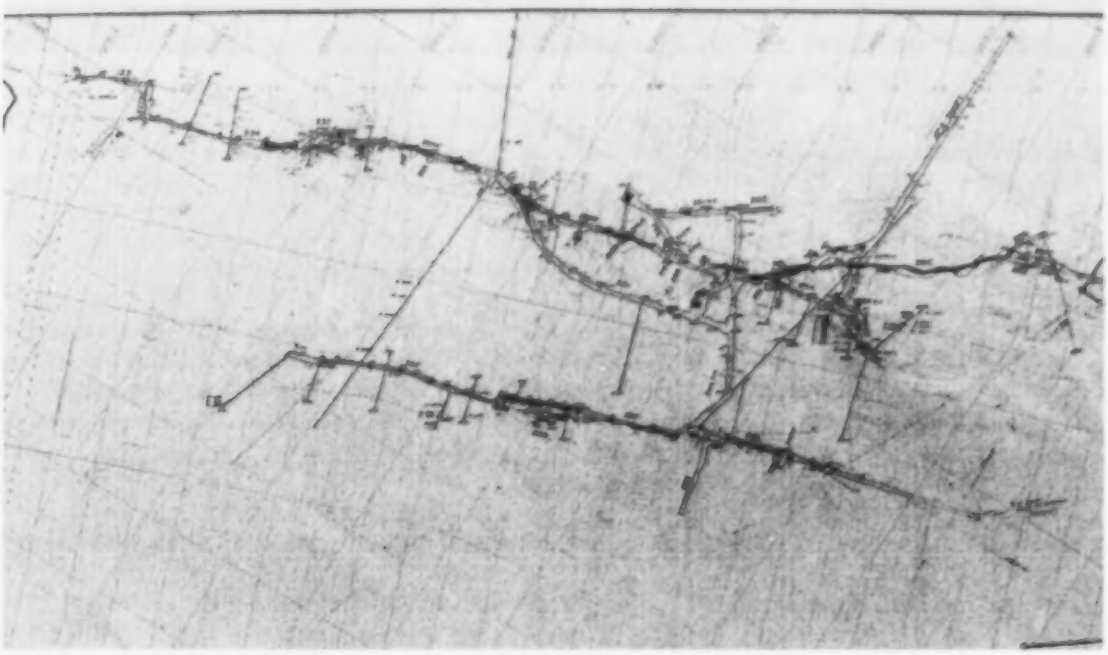

Figure 1. Example of limited amount of geological interpretation in one of the Kirkland Lake Gold properties. Note the presence of both the engineering and mine geology grids; these were used during the digitizing process to georeference the mine level plans. (Plan is 1:100 scale.) (See chart in back pocket for colour version of this figure.)

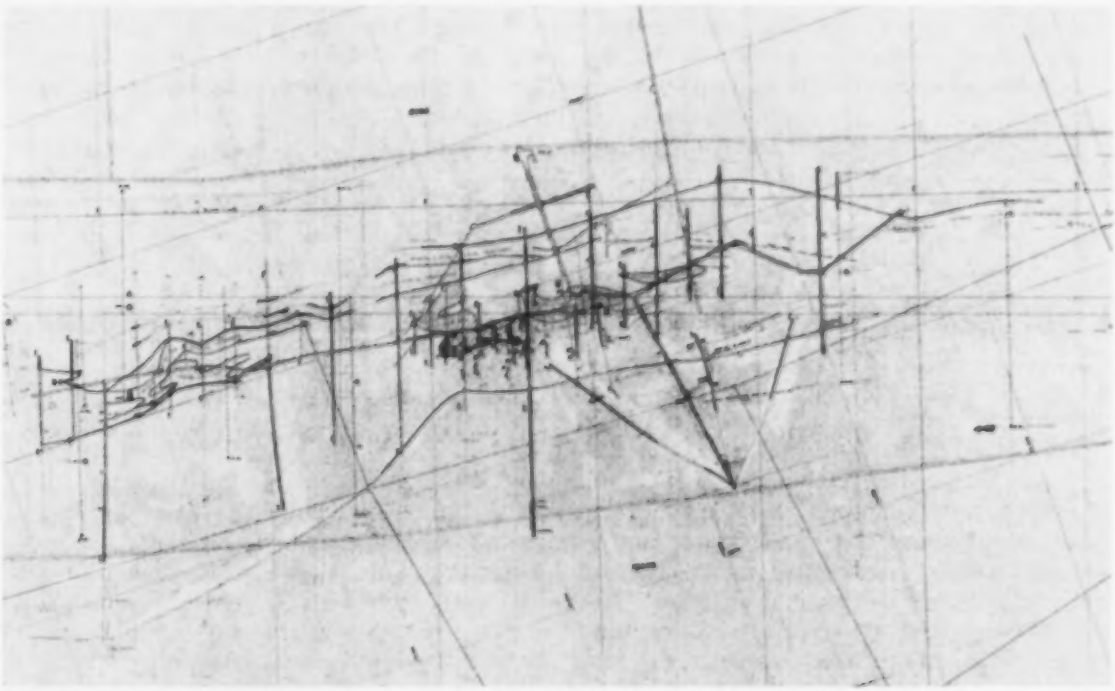

Figure 2. Example of mine level plan with good geological interpretation. (Plan is 1:100 scale.) (See chart in back pocket for colour version of this figure.)

Data Quantity and Quality

In any project of this type there are the inevitable trade-offs between quantity and quality. Some of the deposits had in excess of 17 000 drill holes, involving several thousand descriptive terms. The terminology was rationalized to the OGS legend of Ayer et al. (2004) to facilitate the production of a series of models, and facilitate comprehension of the models across the two mining camps. As a result, detail was lost. Likewise, inconsistent quality of level plans, particularly in the deeper mines, resulted in uneven quality of the model.

DESIGNATION OF MINERALIZED ZONES

Reserves versus Resources

The deposits for which models have been developed in this project range from currently producing mines, such as the Kidd Creek Mine, through to deposits upon which feasibility studies are being conducted, to past producers with production dating back many years. Thus, for many deposits, the mineralization might in the past have been described as "Proven reserves" or "Probable reserves", and such a designation may well be supported by a substantial history of extraction of this material at a profit. However, for many of the deposits described here, current definitions of "reserves" or "resources" are not compliant with definitions of these terms within National Instrument 43-101. Therefore, within this report, the terms "mineralization" or "mineralized zone" are used unless the mineralization as described is known to be compliant with NI 43-101.

Alteration

In some deposits (e.g., Anoki and McBean) alteration has been mapped and is displayed, to an extent, in the model. However, in the majority of deposits, alteration is not a prominent feature in the maps and sections available, and therefore, has not been modelled.

QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance and quality control was an ongoing aspect of the project. It commenced with verification of the quality and completeness of the data received, whether they were analog plans which were then scanned and digitized, or digital files representing either complete donated models or AutoCAD data from which to build the model. Quality assurance and control continued through management of the many coordinate systems in which the data existed. Data received was commonly in local mine coordinates, which may have evolved through the life span of the mine and acquisition of neighbouring properties, resulting in one of the property's local mine grids being translated to match the other property's local mine grid. Examples of where this has occurred are the Anoki and McBean properties, now both owned by Queenston Mining Inc., and Macassa, Kirkland Minerals, Teck-Hughes, Lakeshore and Wright-Hargreaves mines, now owned and operated by Kirkland Lake Gold Inc. The local mine coordinates were stored in FracSIS, and for the final model everything was translated by FracSIS into NAD 83, UTM Zone 17. Once draft models were available, they were reviewed by domain experts from the Greenstone Architecture project, including V. Ispolatov for the Kirkland Lake area, R. Bateman for the Timmins area, and representatives of the various companies that donated data to the project.

Liaison with data donating companies, selection of deposits to be modeled, quality control, and liaison with the funding agency was the responsibility of the Project Steering Committee, made up of K.H. Poulsen, P.Geo., consulting geologist (chair), P.C. Thurston, P.Geo., project director, J.A. Ayer, P.Geo. (Ontario Geological Survey), and R. Calhoun, P.Geo. (Timmins Economic Development Corporation).

The geological aspects of the project were carried out under the supervision of P.C. Thurston, P.Geo. The legend compilation and correlation was carried out by C.A. Hawson, P.Geo. The geological aspects of the modelling process benefited from the expertise of P.Vasak, P.Eng. and the extensive modelling experience of L. Cotesta.

PRODUCTS

Upon completion of the review, quality assurance and quality control stages, the models were formatted for publication through the OGS distribution system. Models are available in 3 formats:

1. Full Digital Product (Miscellaneous Release–Data 157, available separately from this report): this product provides the full model in FracSIS, a database utility from Fractal Technologies that provides the ability to construct individual views of particular features of the model. Features available include conventional views of a given model such as lithologic units, faults, shear zones, alteration zones, assay data where available, drilling data and the integration of the underground information with the most comprehensive version of the surface geology available for the particular deposit. This product enables particular features such as drilling or plans for particular levels or mine infrastructure to be selectively included or excluded to increase ease of manipulation of the model. File size directly affects speed and ease of panning, tilting and rotating of the model.
2. Light Digital Product (Miscellaneous Release–Data 158, available separately from this report): This dataset is designed to be used with Raider3D™, a free model-viewing utility that allows panning, tilting and rotating of particular views of the models. The views incorporated have been chosen to be broadly representative of the geology of the deposit.
3. Analog Product: A hard copy product was produced for distribution as a series of OGS maps (available separately from this report). The maps comprise 3D diagrams showing important aspects of the model for a given deposit, and integrating the model with the surface geology in the vicinity of the deposit. The complete series of maps and the deposit models they portray are listed below.

P.3566: Queenston Mining Inc. – Anoki and McBean deposits
P.3567: St Andrew Goldfields Ltd. – Stock Mine and Clavos Deposit
P.3568: Kirkland Lake Gold Inc. – Macassa Mine
P.3569: Porcupine Joint Venture – Dome, Tisdale and Pamour mines
P.3570: Falconbridge Ltd. – Kidd Creek Mine
P.3571: Millstream Mines Ltd. – Potter Mine
P.3572: Queenston Mining Inc. – Upper Canada Mine
P.3573: Newmont Mining Corp. – Holt-McDermott Mine
P.3574: Newmont Mining Corp. – Harker-Holloway Mine
P.3575: Kirkland Lake Gold Inc. – Teck-Hughes, Wright-Hargreaves and Lakeshore mines

Regional Geological Setting of Deposits Modelled

This project has modelled 2 volcanogenic massive sulphide (VMS) deposits and 18 lode gold deposits. The deposits occur within or near the Timmins area and the Kirkland Lake area of the Abitibi greenstone belt. Many of the deposits modelled have not been formally described in the literature with some notable exceptions, such as Kidd Creek (Barrie et al. 1999) and some of the gold deposits (Fryer et al. 1979; Kerrich 1986). Other deposits that were exploited during the interval 1920-1960 were described only in provincial government reports (e.g., Thomson 1948; Thomson et al. 1948).

The Abitibi greenstone belt, extending through northeastern Ontario and northwestern Quebec, is the largest continuous greenstone belt in the world. It is composed of so-called "Keewatin" or older greenstones ranging from 2790 Ma to 2697 Ma, unconformably overlain by successor basins or so-called "Timiskaming" type assemblages, and intruded by numerous granitic bodies coeval with the majority of volcanic and structural events affecting the belt.

The Abitibi greenstone belt is cut by 2 major strike-slip faults or deformation zones: in the northern part of the belt is the Porcupine–Destor deformation zone; in the southern part is the Cadillac–Larder Lake deformation zone. Each of these structures has a strike length of hundreds of kilometres. These major structures are spatially and genetically associated with subsidiary structures branching off the main structure. The Timiskaming-type assemblages are spatially and genetically associated with the major structures.

The Kirkland Lake camp, in the southern part of the Abitibi greenstone belt, extends for approximately 40 km between the towns of Kirkland Lake and Virginiatown. The mines in this area are spatially related to the east-trending Cadillac–Larder Lake deformation zone, a 300 km long ductile and/or brittle shear zone ranging from 10 to 200 m wide in outcrop and contained within a structural corridor up to 5 km wide. The Cadillac–Larder Lake deformation zone is characterized by heterogeneous deformation in the form of strong foliation, tight folding and development of splays and subsidiary shears. In the Kirkland Lake area, the Cadillac–Larder Lake deformation zone, locally referred to as the Larder Lake Break, occurs at the contact between the Timiskaming assemblage of metasedimentary and metavolcanic rocks to the north and a schistose ultramafic unit of the Larder Lake volcanic assemblage to the south.

Volcanogenic Massive Sulphide (VMS) Deposit Models

The VMS-mineralized metavolcanic assemblages in Ontario are the Kidd–Munro assemblage (2711-2718 Ma), the Blake River assemblage (2701-2697 Ma) and the Tisdale assemblage (2710-2703 Ma).

VMS mineralization is a form of syngenetic mineralization developed through hydrothermal activity related to eruption and/or emplacement of the volcanic units associated with the mineralization (Franklin 1995). Therefore, models of this type of mineral deposit need to emphasize volcanic stratigraphy and, in some instances, the related plutonic units. Conversely, the importance of faults and shear zones is minor and generally not emphasized.

MILLSTREAM MINES LTD.: POTTER MINE

General Information

- Mine site location: Munro Township (see Ayer et al. 1999)
- Deposit type: VMS
- Property owner: Millstream Mines Ltd.
- Data donor(s): Millstream Mines Ltd., Ontario Geological Survey and Dave Gamble Geoservices Inc.
- Model built by: L. Cotesta, with assistance of P. Vasak, C.A. Hawson, P.Geo., J. Whitmore, G. Wang, and B. Anderson and G. Yang
- Checked by: E. Harrison (President), Millstream Mines Ltd., D. Gamble, P.Geo., Dave Gamble Geoservices Inc., J. Gingerich (professional geophysicist), and P.C. Thurston, P.Geo., MERC.

Background

The Potter Mine is located in Munro Township, some 80 km east of Timmins, Ontario. Originally brought into production in 1967, the mine closed in 1972. During its short tenure, 477 572 tons of ore were milled grading 1.63% Cu and 1.5% Zn with 0.1-0.5 ounces per ton Ag and trace amounts of Au (Gamble 2000).

Deposit Setting

The Potter Mine of Millstream Mines Ltd. is a VMS deposit that is situated near the midpoint of the lateral extent of the 2718-2711 Ma Kidd–Munro assemblage. The Kidd–Munro assemblage extends from northwest of Timmins eastward into Québec. The Kidd–Munro assemblage is cut by numerous mafic to ultramafic intrusions, such as the immediately adjacent Centre Hill intrusion, which is of Tisdale assemblage age (U-Pb zircon age, M. Hamilton, University of Toronto, personal communication, 2005). The Kidd–Munro assemblage in the mine area consists of a basal sequence of komatiites overlain by tholeiitic metavolcanic rocks. The tholeiitic rocks include a unit of vent-proximal spatter deposits, which are more permeable than the surrounding pillowed flows. The mineralization is a zone in which chalcopyrite and pyrite replace both fragments and matrix of the spatter deposits and infill the matrix of this unit.

Data Donors and Sources

HORIZONTAL AND VERTICAL SLICES

A combination of Dave Gamble Geoservices Inc. and Millstream Mines Ltd. provided MIRARCO with several horizontal and vertical geological cross sections of the deposit on paper. These were then scanned by BLAZE I.T. and stored as digital images. These sections and plans were interpreted from a recent drilling campaign of 36 holes in which Dave Gamble Geoservices Inc. has confidence, and thus formed the basis of the 3D mineral deposit model.

The vertical cross sections (at 1:2000) are:

- 7730

- 7810
- 7850
- 7910
- 7970
- 8030
- 8090

The horizontal plans (at 1:1000) are:

- Detailed surface map (1:2000)
- Depth: 116 m = 200 masl
- Depth: 316 m = 0 masl
- Depth: 436 m = -120 mbsl
- Depth: 536 m = -220 mbsl
- Depth: 716 m = -400 mbsl
- Depth: 916 m = -600 mbsl

Note that the shaft elevation is at 316 masl. UTM and mine grid coordinates are on the plans.

DRILL-HOLE DATA

Dave Gamble Geoservices Inc. also provided MIRARCO with a partial drill-hole database stored in Access™ format. This database contained 18 drill holes with header, survey, lithologic and assay data. The remaining drill-hole logs were provided on paper from Dave Gamble Geoservices Inc., for a total of 37 holes.

GEOPHYSICAL DATA

Three time-domain IP (Induced Polarization) horizontal sections showing total chargeability, and another 3 sections portraying apparent resistivity with depth, were supplied by Millstream Mines Ltd. (survey done by Quantec IP Inc. in 1999). These were supplied on 3.5-inch floppy diskettes.

Also provided in digital format from Millstream Mines Ltd. were several pulse EM (electromagnetic) surveys along boreholes. Note that this data is not included in the FracSIS model.

Modelling Procedure

DATA IMPORT AND MODELLING CONVENTIONS

1. Drilling
    a. A Gemcom™ database was deconstructed and the following ASCII files were produced for incorporation into the model:
        i. Collar information (surface location X, Y, Z)
        ii. Survey (depth, down-hole dip and azimuth)
        iii. Lithology (from, to, Litho Code)
        iv. Assay files (from, to, % copper, % zinc and % cobalt)
    b. These files were then imported into gOcad to help with the 3D interpretation of the 3D mineral deposit model.

2. Paper geological maps, geological plans and cross sections and mine infrastructure
    a. All geological maps, sections and plans were scanned by BLAZE I.T.
    b. This data was then digitized and georeferenced in ArcView™.
    c. Polylines were then exported from ArcView and imported into gOcad, where the polylines were filled and coloured as polygons.
3. 3D contacts, faults and solids
    a. Once these level plans and cross sections were properly "stacked," they were very useful in aiding with the 3D interpretation of the deposit.
    b. The polylines were then used to build the 3D surfaces.
4. Mine levels and stopes
    a. NOTE: due to the geological nature of the project, the mine infrastructure is approximate at best and is only to be used for visualization purposes.
    b. The 3D mine infrastructure was created by digitizing and georeferencing the drift outlines and then "extruding" these to create 3D solids of the drifts. For simplification, the change in elevation on a single level is neglected, i.e., the levels are essentially flat. The same procedure was performed for the stopes.
5. Geophysical data
    a. Three time-domain IP horizontal sections of chargeability at various depths were provided in Geosoft™ format. Data was imported.
        i. Note that "Numeric Attribute map for Real IP Chargeability.fvp" and "Numeric Attribute map for Real IP Chargeability Legend Editor.fvp" are FracSIS proprietary file formats applied to the chargeability datasets. These files store the colour maps with proper ranges to view the datasets. These files are stored in the project folder within the "Property files (fvp)" subfolder.
    b. Three time-domain IP horizontal sections of resisitivity at various depths
        i. Note that "Numeric Attribute map for Real IP Resistivity.fvp"is a FracSIS property file to be applied to the resistivity datasets. The file stores the colour map with proper ranges to view the datasets. This file is stored in the project folder within the "Property files (fvp)" subfolder.
    c. Several down-hole pulse EM surveys were processed, however, due to visualization constraints, these were not included in the FracSIS model. They are, however, shown in a Raider3D model (MRD 158, available separately from this report) and on Preliminary Map P.3571 (also available separately from this report). Figure 3 shows a screen capture of the 3D model similar to that shown on map P.3571.

Figure 3. Partial 3D deposit model of the Potter Mine showing interpreted geological maps at depth (D. Gamble, personal communication, 1999), geology-coded drill holes, faults, minor komatiitic flows, interpreted mineralization zone and the folded tholeiitic metavolcanic contact that hosts the deposit. Original mine has 8 levels to a depth of approximately 330 m below surface; the shaft has been artificially extended to the interpretation depth of approximately 900 m below surface. (See chart in back pocket for colour version of this figure.)

DATA VALIDATION

Data validation was ongoing throughout the construction of the model by closely working with D. Gamble, who was identified as the main data and modelling contact by Millstream Mines Ltd. Also, a Virtual Reality session was held with various interdisciplinary experts brought in by Millstream Mines Ltd. to perform final data validation for the deposit model.

LEGEND NOMENCLATURE

For model construction, the mine's legend nomenclature was utilized. This nomenclature was later converted to conform to the OGS legend used in Ayer et al. (2004). Correlation to the OGS compilation legend was carried out by C.A. Hawson, P.Geo., and approved by D. Gamble, P.Geo. (Dave Gamble Geoservices Inc).

Table 2 shows the original Potter Mine nomenclature used on maps and in some drill holes, and the resulting correlation to the OGS legend used in Ayer et al. (2004).

Table 2. Various Potter Mine geology nomenclatures correlated with the legend used by OGS in Ayer et al. (2004).

Various Mine Geology Nomenclatures	OGS Reference	Final Potter Legend
A_Argillites	7e	Chemical_Sediment_graphitic_facies
A_Argillites_Massive_Sulphides	7c	Chemical_Sediment_Sulphide_facies_graphitic
A_Argillites_Sulphides	7c	Chemical_Sediment_Sulphide_facies_graphitic
Ac_Th_Surface	7d	Chemical_Sediment_Silicate_facies
Bds_Perperitic_Basalt	2p	Basalt_peperitic_texture
CE_Cherty_Exhalite	7d	Chemical_Sediment_Silicate_facies
CE_Cherty_Exhalite_Sulphides	7c	Chemical_Sediment_Sulphide_facies_siliceous
Dd_Diabase_Dyke_Surface	15a	Matachewan_Diabase_Dyke
Dd_DiabaseDyke	15a	Matachewan_Diabase_Dyke
Dio_Diorite	10a	Diorite_gabbro_melagabbro
DioD_DioriteDyke	10a	Diorite_gabbro_melagabbro
Faults	FZ	Fault
Faults_Thrust	FZ	Fault
Fpd_Feldspar_Porphyritic_Dykes	11b	Quartz_and_or_feldspar_porphyry
Fpd_Feldspar_Porphyritic_Dykes_Surface	11b	Quartz_and_or_feldspar_porphyry
FZ_Fault_Zone	FZ	Fault
G0_Gabbroic_Pyrrhotite_Chalcopyrite	10a	Diorite_gabbro_melagabbro
Gd_Gabbroic_Dykes	10a	Diorite_gabbro_melagabbro
Ghpc_Gabbroic_Hornblend_Phyric	10a	Diorite_gabbro_melagabbro
Ghpc_Gabbroic_Hornblend_Phyric_Surface	10a	Diorite_gabbro_melagabbro
Gi_Gabbro_Pyroxene_Feldspar	10a	Diorite_gabbro_melagabbro
High_Ductile_Strain_Zone	FZ	Fault
Id_Intermediate_Dykes_Surface	3	Intermediate_felsic_Metavolcanic_Rocks_Intrusions
KBf_Komatiitic_Basalt_Flows	1B	Komatiitic_Basalt
KBf_Komatiitic_Basalt_Flows_Sulphides	1Bs	Komatiitic_Basalt_with_Sulphides
Kf_cx_Komatiitic_Flows_Fractured_Pyroxene_Olivine	1K	Komatiite
Kf_cxe_Komatiitic_Flows_Crowded_Olivine_Euhedral	1K	Komatiite
Kfcx_Komatiitic_Flows_Oikocrystic	1K	Komatiite
Kfp_Komatiitic_Flows_Peridotitic	1K	Komatiite
Kfs_Komatiitic_Flows_Spinifex	1c	Komatiite_Spinifex
KUMFS_Komatiitic_UM_Lay_Flow_Seq	1L	Komatiitic_flow_sequence_layered
KUMFS_Komatiitic_UM_Lay_Flow_Seq_Sulphides	1Ls	Komatiitic_flow_sequence_layered_with_sulphides
LG_Leuco_Gabbro_Surface	10c	Anorthositic gabbro, leucogabbro

Various Mine Geology Nomenclatures	OGS Reference	Final Potter Legend
Massive_Sulphide_Additional	2S	Mafic_Metavolcanic_rocks_Massive_sulphides
Md_HORNBLENDE_PORPHYRITIC_MAFIC_DYKE	10h	Porphyritic_Mafic_Intrusive
Md_Mafic_Dyke	10a	Diorite_gabbro_melagabbro
Md_Mafic_Dyke_Sulphides	10as	Diorite_gabbro_melagabbro_with_sulphides
MS_Massive_Sulphide	2S	Massive_Sulphides
Mt_Ac_Mafic_Ash_Tuffs_Cherty_Argillites_Surface	7e	Chemical_Sediment_graphitic_facies_siliceous
OB_OVERBURDEN	OB	Overburden
Pe_Intrusive_Peridotites_Surface	9a	Ultramafic_peridotite_pyroxenite
Pe_Peridotite	9a	Ultramafic_peridotite_pyroxenite
Px_Intrusive_Pyroxenite_Surface	9a	Ultramafic_peridotite_pyroxenite
Px_Pyroxenite	9a	Ultramafic_peridotite_pyroxenite
Qs_Pleistocene_Glacial_Sediments	OB	Overburden
S_Massive_Sulphide	2S	Mafic_Metavolcanic_rocks_Massive_sulphides
Semi_MS_LC	2Sm	Mafic_metavolcanic_rocks_Semi_Massive_sulphides
SKUMFBTB_Sheared__Komatiitic_UM_Basalt_Tuff_Breccia	1f	Schistose_textured_Komatiite
SKUMFBTB_Sheared__Komatiitic_UM_Basalt_Tuff_Breccia_Sulphide	1fs	Schistose_textured_Komatiite_with_sulphides
SMS_Semi_Massive_Sulphide	2Sm	Mafic_metavolcanic_rocks_Semi_Massive_Sulphides
Sulphide_Enveloppe_Beautified	2S	Mafic_Metavolcanic_rocks_Massive_sulphides
SZ_Shear_Zone	SZ	Fault
TBd_Tholeiitic_Basalt_Dyke	2T	Mafic_Tholeiite
TBd_Tholeiitic_Basalt_Dyke_MassiveSulphides	2Tms	Mafic_Tholeiite_with_massive_sulphides
TBd_Tholeiitic_Basalt_Dyke_Sulphides	2Ts	Mafic_Tholeiite_with_sulphides
TBd_Tholeiitic_Basalt_Dykes	2T	Mafic_Tholeiite
TBf_Thoelitic_Basalt_Flows	2T	Mafic_Tholeiite
TBf_Tholeiitic_Basalt_Flow_Sequence	2T	Mafic_Tholeiite
TBf_Tholeiitic_Basalt_Flow_Sequence_Sulphides	2Ts	Mafic_Tholeiite_with_sulphides
TBfp_Tholeiitic_Basalt_Flows_Plagioclase_Porphyritic	2T	Mafic_Tholeiite
TBfv_Thoelitic_Basalt_Flows_Variolitic	2T	Mafic_Tholeiite
Th_Tholeiitic_Hyaloclastics	2d	Hyaloclastite
Th_Tholeiitic_Hyaloclastites	2d	Hyaloclastite
Th_Tholeiitic_Hyaloclastites_MassiveSulphides	2dms	Hyaloclastite_with_Massive_Sulphides
Th_Tholeiitic_Hyaloclastites_Semi_Massive_Sulphides	2ds	Hyaloclastite_with_Sulphides
Th_Tholeiitic_Hyaloclastites_SulphidesMatrix	2ds	Hyaloclastite_with_Sulphides
Tha_Thoelitic_hayaloclastites_agglomerates	2d	Hyaloclastite

Note that all relevant FracSIS legend files are stored in the project folder as property files (*.fvp) within the "Property files (fvp)" subfolder. Here is a list of the relevant property files related to legends:

- Potter_Rocktype_OGS_Converted_Codes.fvp – final legend used to apply OGS colouring to Potter rock types.
- OGS_Rocktype_Legend_RGB.fvp – OGS legend to be applied to the regional OGS "cut-outs" for the ROCK_TYPE field.

COORDINATE SYSTEM TRANSFORMATIONS

All data was initially received in the Potter Lithology Grid, as defined by Millstream. This local grid was defined and stored in the FracSIS database so that a coordinate transform could be applied within the FracSIS software. The coordinate system file was also stored in the project folder in the "Coordinate System Definitions (csd)" subfolder as a file called "Millstream_Potter_Litho_Grid.csd". This definition may be used/imported in other projects (e.g., gap analysis for Holloway and Holt-McDermott mines). The local grid system is defined as follows:

Target projected coordinate system: NAD83, UTM Zone 17N

- Transform from local point:
  - Easting: 7651.83 m
  - Northing: 3165.6 m
  - Height: 0 m
- To projected point:
  - Easting: 557652.15 m
  - Northing: 5383169.31 m
  - Height: 0 m
- No rotation

Scope for Further Improvement

As with all modelling, there is always room for improvement, and interpretations are constantly evolving as a result of data integration and 3D modelling in general. For the Potter deposit, the 3D interpretation was made based on an initial interpretation that was done in 2D from projected drill holes onto plans and sections. At intermediate depths there is less drilling constraining the deposit and, as a result, there is greater uncertainty in interpretation of the mineralized zone for this area (Figure 4). Closer to surface, the geology is much better constrained due to its close proximity to the historical mine workings. At depth, long directional drilling was able to constrain the lower portion of the deposit. It is suspected that with the new 3D model and better data integration, this portion of the model may be re-interpreted (*see* Figure 4).

If additional drilling becomes available, a sub-regional 3D mineral deposit model may be constructed that extends further to the east.

Figure 4. Mineralized zone of Potter Mine in relation to geological plans, demonstrating the relationship between mineralization and the various lithological units. Note that the interpretation of the geology is less constrained at intermediate depth in the deposit and displays mineralized offshoots. View is looking southeast. (See chart in back pocket for colour version of this figure.)

FALCONBRIDGE LTD.: KIDD CREEK MINE

General Information

- Mine site location: Kidd Township (see Ayer and Trowell 1998)
- Deposit type: VMS
- Property owner: Falconbridge Ltd.
- Data donor(s): Falconbridge Ltd., Ontario Geological Survey (OGS)
- Model supplied by: Falconbridge Ltd.
- Model compiled by: J. Whitmore, C.A. Hawson, P.Geo., and G. Wang
- Modifications reviewed by: D. Duff, P.Geo., Falconbridge Ltd.

Background

Kidd Creek Mine, a world-class volcanogenic massive sulphide (VMS) deposit lying in Kidd Township some 27 km north of Timmins, Ontario, was discovered by Texas Gulf Sulphur Co. in 1963. It was purchased by Falconbridge Limited in 1986. Production of copper, zinc, indium, cadmium and silver began via open pit operations in 1966, followed by underground operations accessed by 3 shafts known as the No.1 (1969), No.2 (1974) and No.3 (1989) mines. Development of Mine D, which will extend production from 2100 to 3100 m below surface, is currently underway.

As of 2002, the Kidd Creek deposit had produced 124.22 million tonnes (Mt) grading 6.18% Zn, 2.31% Cu, 0.22% Pb and 87 g/t Ag (Gibson et al. 2003). In 2003, 2.1 Mt of ore grading 2.30% Cu and 4.27% Zn was mined. Current proven reserves are 12.59 Mt grading 1.86% Cu, 5.60% Zn and 71 g/t Ag, with probable reserves of 8.24 Mt grading 2.23% Cu, 7.00% Zn and 53 g/t Ag (Falconbridge Ltd., 2003 Annual Report).

Deposit Setting

The Kidd Creek Mine is found toward the western end of the Kidd–Munro assemblage, which, in the mine area, consists of a sequence of tholeiites and komatiites overlain by a local-scale sequence of rhyolites—the immediate host rock unit for the deposit. The rhyolites are within the Kidd Creek Volcanic Complex, a complexly folded sequence that includes the Mine sequence and the coeval Kidd 66 and the Kidd West basins, respectively west and east of the mine. The Kidd–Munro assemblage is truncated to the south by metasedimentary rocks of the Porcupine assemblage. The deposit is over 100 million tonnes. The large size of the deposit has been explained by development of a large hydrothermal system related to the underlying komatiitic flows and coeval intrusions persisting until a large deposit had developed.

Data Donors and Sources

1. Falconbridge Ltd. provided a mature model produced in gOcad of the Kidd Creek Mine.
2. Falconbridge also provided additional information as AutoCAD drawing files.
3. Surface map information was provided by the Ontario Geological Survey (Ayer et al. 2004).

4. All surface map information from Falconbridge and from the OGS was provided in digital form in North American Datum 1983 (NAD83), UTM Zone 17N grid coordinates.

5. The legend for the surface geology and, where appropriate, the underground geology, was brought into conformity with the regional-scale OGS legend used in Ayer et al. (2004) by C.A. Hawson, P.Geo., and verified by D. Richards, P.Geo. (Falconbridge Ltd.).

6. Legend colours are derived from those used in Ayer et al. (2004). However, the three-dimensional views of the mines require the use of shading and oblique "illumination" to bring about the three-dimensional appearance of the deposits on a paper product. Therefore, there are small variations from the colours used by Ayer et al. (2004) to bring about shading.

7. Geographic data, Landsat imagery and geophysical maps were extracted from Ayer et al. (2004).

Modelling Procedure

The initial model was compiled in gOcad by staff of Falconbridge Ltd. Additional AutoCAD rock surfaces, local surface geology and mine infrastructure data was converted to .dxf format and imported into the gOcad project. For example, the graphite and dacite units were built from the provided AutoCAD level plans. Rock units were correlated to the OGS legend by C.A. Hawson, P.Geo. (Table 3) and checked by D. Richards, P.Geo.

The final FracSIS model compilation includes the gOcad model objects and the surface geology, geophysics, Landsat image and geographic information (roads, rail, rivers, and lakes) from Ayer et al. (2004), which was extracted using using ArcGIS software.

The Kidd Creek coordinate system (KCCS) is tied in to NAD 27, UTM Zone 17N as follows:

1. 471920.867 Easting = 471913.69 KCCS East
2. 5392478.06 Northing = 5392249.84 KCCS North
3. -3048.0 Elevation = 0.0 KCCS
4. Rotation = 0 degrees counterclockwise

Model validation was was carried out in consultation with mine personnel at each stage of the compilation process.

Table 3. Original Kidd Creek legend supplied by Falconbridge Ltd., and the legend as correlated to the OGS compilation legend used in Ayer et al. (2004).

KIDD CREEK LEGEND			APPROVED KIDD CREEK LEGEND	
Code	Rock Type	Colour		
1	Ultramafic Volcanic (also called Talc-Carb)	violet	1	Ultramafic (to Mafic) Metavolcanic Rocks/Intrusions
2	Mafic Volcanic	palegreen	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
3	Intermediate volcanic	gray60	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions
4	Felsic Volcanic	yellow	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
5	sediment	gray20	6	Clastic Metasedimentary Rocks
6	Ultramafic Intrusive	violet	9	Ultramafic Intrusive Rocks
7	Mafic Intrusive	forestgreen	10	Mafic Intrusive Rocks
8	Intermediate Intrusive	skyblue	12	Felsic to Intermediate Intrusive Suite
9	Felsic Intrusive	yellow	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
10	Diabase	darkgreen	15	Diabase Dikes
5g	Graphitic Sediment	gray20	7e	Chemical Sediment - Graphite Facies
A	Andesite/Diorite (Gabbro)	white	10	Mafic Intrusive Rocks
A/D	Andesite/Diorite (Gabbro)	green	10	Mafic Intrusive Rocks
A/D1	Andesite/Diorite (Gabbro)	green	10	Mafic Intrusive Rocks
A/D2	Andesite/Diorite (Gabbro)	forestgreen	10	Mafic Intrusive Rocks
A/D3	Andesite/Diorite (Gabbro)	cyan	10	Mafic Intrusive Rocks
A/D4	Andesite/Diorite (Gabbro)	cyan	10	Mafic Intrusive Rocks
A_D	Andesite/Diorite (Gabbro)	green	10	Mafic Intrusive Rocks
A_D1	Andesite/Diorite (Gabbro)	green	10	Mafic Intrusive Rocks
A_D2	Andesite/Diorite (Gabbro)	forestgreen	10	Mafic Intrusive Rocks
A_D3	Andesite/Diorite (Gabbro)	cyan	10	Mafic Intrusive Rocks
A_D4	Andesite/Diorite (Gabbro)	cyan	10	Mafic Intrusive Rocks
AD1	Andesite/Diorite (Gabbro) fine	green	10	Mafic Intrusive Rocks
AD2	Andesite/Diorite (Gabbro) coarse	forestgreen	10	Mafic Intrusive Rocks
AM		white		
BA	Black Argillite (Graphitic Argillite)	gray20	7e	Graphite Facies
BC	Broken Core	gray50		
BF	BackFill (mining term)	white		
BK	Basaltic Komatiite	violet	1b	1B Basaltic komatiite
BT	Break Through	white		
CAS	Casing	white		
CB	Crackle Brecciated Massive Rhyolite	orange	4a	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
D	Basalt/Andesite	palegreen	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
D1	Basalt/Andesite	palegreen	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
D2	Basalt/Andesite	palegreen	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
DV	Basalt/Andesite	palegreen	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions

KIDD CREEK LEGEND			APPROVED KIDD CREEK LEGEND	
EOH	End of Hole	white		
FPR	Feldspar - Porphyritic Rhyolite	yellow	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
FZ	Fault Zone	blue		Fault
fz	Fault Zone	blue		Fault
G	Graphitic Sediment	gray80	7e	Chemical Sediment - Graphite Facies
GD		white		
LC	Lost Core	white		
MBA	Mixed Black Argillite (mixed graphitic argillite)	gray20	7e	Chemical Sediment - Graphite Facies
MF	Mixed Volcaniclastic Fragmental (Felsic-Mafic Fragments)	yellow	4c	4c Tuff breccia, pyroclastic breccia
MGT	Magnesium Tholiite (Basalt)	violet	2M	2M High-magnesium tholeiite
MMF	Mixed Mafic Fragmental	cadetblue	2g	2g Tuff breccia, pyroclastic breccia
MQP	Mixed Quartz Porphyritic Rhyolite	pink	4d	4d Porphyritic
MRF	Mixed Rhyolite Fragmental	yellow	4c	4c Tuff breccia, pyroclastic breccia
MS	Massive Sulphide	red	ORE	ORE
MSC	Massive Sulphide Mainly Chalcopyrite	red	ORE	ORE
MSCS	Massive Sulphide Chalcopyrite-Sphalerite	red	ORE	ORE
MSP	Massive Sulphide Mainly Pyrite	red	ORE	ORE
MSPO	Massive Sulphide Mainly Pyrrhotite	red	ORE	ORE
MSPY	Massive Sulphide Mainly Pyrite	red	ORE	ORE
MSS	Massive Sulphide Mainly Sphalerite	red	ORE	ORE
MSSPH	Massive Sulphide Mainly Sphalerite	red	ORE	ORE
MV	Mafic Volcanic	palegreen	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
NAVI	Navi Cut (wedge type)	white		
NC	No Core	white		
nc	No Core	white		
ob	Overburden	white		overburden
PCR	Picritic Ultramafic	aquamarine	9	Ultramafic Intrusive Rocks
PK	Komatiite	violet	1K	Komatiite
QFP	Quartz Feldspar Porphyritic Rhyolite	pink	4	4d Porphyritic
QP	Quartz Porphyritic Rhyolite	pink	4	4d Porphyritic
QV	Quartz Vein	white		
qv	Quartz Vein	white		
R	Rhyolite	yellow	4	4 Unsubdivided
RAL	Rhyolite Agglomerate Volcaniclastic	yellow	4	4c Tuff breccia, pyroclastic breccia
RLST	Rhyolite Lapillistone Volcaniclastic	yellow	4	4b Tuff, lapilli tuff
RLT	Rhyolite Lapilli Tuff Volcaniclastic	yellow	4	4b Tuff, lapilli tuff
RPQ	Quartz Porphyritic Rhyolite	yellow	4	4d Porphyritic
RT	Rhyolite Tuff	yellow	4	4b Tuff, lapilli tuff
RTPQ	Rhyolite Tuff Quartz Porphyritic	yellow	4	4b Tuff, lapilli tuff, 4d Porphyritic
S	Serpentenite (Ultramafic)	violet	1	altered ultramafic
SM	Semi-Massive Sulphide	red	ORE	ORE

KIDD CREEK LEGEND			APPROVED KIDD CREEK LEGEND	
SMS	Semi-Massive Sulphide	orangered	ORE	ORE
TC	Talc-Carbonate (Ultramafic)	violet	1	altered ultramafic
UNK	Unknown	white		
USED in gOcad MODEL			**PROPOSED LEGEND**	
2			2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
2V			2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
2W			2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
2YB			2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
2YZ			2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
3HT			3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions
4			4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
4Z			4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
5			6	Clastic Metasedimentary Rocks
5g			7e	Chemical Sediment - graphite facies
6			9	Ultramafic Intrusive Rocks
7			10	Mafic Intrusive Rocks
9			4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
Diabase			15	Diabase Dikes - No Category Given
KiddR			4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
LoTi			2T	Tholeiite
MS			ORE	ORE
MV			2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
QP			4d	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
Stringer			ORE	ORE
UM			1	Ultramafic (to Mafic) Metavolcanic Rocks/Intrusions

Lode Gold Deposit Models

Lode gold deposits (alternatively mesothermal lode gold, orogenic lode gold; Hodgson 1993) are deposits rich in Au ± Ag that are spatially associated with major strike-slip shear zones in rocks of a variety of ages worldwide. The controls on the gold mineralization are mainly structural. Mineralization is largely related to these major structures and related subsidiary structures. There may be some association with particular rock types, such as iron formation, high-iron volcanic rocks such as tholeiitic or komatiitic volcanic units, or with late orogenic high-level intrusive rocks (i.e., "porphyry"), or late orogenic granitic to syenitic plutons. Therefore, as the major controls for this style of mineralization are structural, the models emphasize shear zones and/or faults.

Porcupine–Destor Fault-Related Gold Deposits

Gold production in the Timmins camp has totalled over 66 million ounces to the end of 2003 (Atkinson et al. 2005) and the region to the east of the Timmins camp had production in excess of 2.1 million ounces. Gold was discovered in Timmins in 1910 with early production coming from the Dome Mine. The gold deposits of the Timmins camp are spatially associated with the Porcupine–Destor fault. The fault extends eastward into Québec, and east of Timmins there are a number of subsidiary splay structures such as the Pipestone fault and the Munro fault. The deposits are typical lode gold deposits associated with quartz, carbonate, and quartz-carbonate vein systems. The mineralization lies within basalts and komatiites of the Tisdale assemblage and the unconformably overlying metasedimentary rocks of the Porcupine and Timiskaming assemblages. The major deposits to the east along the Porcupine–Destor fault and its splay are the Holloway Mine and the Holt-McDermott Mine, both owned by Newmont Mining Corporation. The geological setting of both deposits is broadly similar to the Timmins camp in the sense that the deposits are spatially associated with the Porcupine–Destor fault. In detail, the settings of these deposits do differ and those differences are highlighted in later sections of the report.

In the Timmins camp specifically, the deposits are related to a lengthy history of deformation. Ankerite clasts in Timiskaming assemblage conglomerate (Dubé et al. 2003) clearly demonstrate pre-Timiskaming assemblage (D_2) mineralization. Ankerite veining in the Tisdale assemblage at the Dome Mine and the Aunor-Delnite Mine crosscuts Tisdale assemblage rocks, as they are cut by later quartz tourmaline veins.

Most Timmins camp gold post-dates Timiskaming assemblage sedimentation with, for example, McIntyre Cu-Au-Ag-Mo mineralization crosscutting (Burrows et al. 1993) albitite dykes and Timiskaming assemblage rocks. Hollinger mineralization, representing 50% of Timmins–Porcupine gold, consists of gold-mineralized quartz-filled fractures which formed during D_3 (Bateman et al. 2004). D_4 mineralization is represented by the Pamour Mine, and other deposits along the Porcupine–Destor fault.

ST ANDREW GOLDFIELDS LTD.: STOCK MINE AND CLAVOS DEPOSIT

General Information

- Mine site locations: Stock Township (see Ayer et al. 1999)
- Deposit type: Archean lode gold
- Property owner: St Andrew Goldfields Ltd.
- Data donor(s): St Andrew Goldfields Ltd., Ontario Geological Survey (OGS) and the Mineral Exploration Research Centre (MERC)
- Model supplied by: St Andrew Goldfields Ltd.
- Model compiled by: J. Whitmore, L. Cotesta, C.A. Hawson, P.Geo., and G. Wang
- Modifications reviewed by: W. Reid, P.Geo., St Andrew Goldfields Ltd.

Background

STOCK MINE

Stock Mine is located in Stock Township, approximately 50 km east of Timmins, Ontario. Prior to ceasing production, it yielded some 131 000 ounces of gold from 824 000 tonnes of ore over the period 1988 to 1994 and 2000. Access to the underground workings is via a 275 m deep shaft and a ramp from the 140 m level to approximately 330 m below surface (Info-Mine 2004).

Indicated reserves are currently 3000 tonnes at 8.0 g/t Au, with inferred reserves of 32 000 tonnes at 8.1 g/t (St Andrew Goldfields Ltd., 2003 Annual Report).

CLAVOS DEPOSIT

The Clavos deposit is located in German Township, approximately 10 km northwest of the Stock Mine. Current development consists of an 1800 m decline ramp to a depth of 275 m for ore delineation and exploration. Production levels, spaced at 50 m vertical intervals, are planned from the 100 m level downwards.

Indicated reserves are 753 000 tonnes at 7.3 g/t Au, with inferred reserves of 452 000 tonnes at 8.9 g/t (St Andrew Goldfields Ltd., 2003 Annual Report).

Deposit Setting

The Stock Mine is an Archean lode gold deposit associated with the Porcupine–Destor deformation zone. The mineralization is in carbonate-altered ultramafic intrusions and flows of the Kidd–Munro assemblage and coeval intrusive rocks. Gold occurs as free gold in grey and green carbonate veins and breccia.

The Clavos deposit is hosted by altered andesitic and komatiitic rocks on the western extension of the Pipestone fault, a second-order fault associated with the Porcupine–Destor deformation zone.

Data Donors and Sources

1. St Andrew Goldfields Ltd. provided mature FracSIS model databases for both Stock and Clavos mines.

2. Additional surface map information was provided by the Ontario Geological Survey (Ayer et al. 2004).

3. The surface map information was provided in digital form in North American Datum 1983 (NAD83), UTM Zone 17N grid coordinates.

4. The legend for the surface geology and, where appropriate, the underground geology, has been brought into conformity with the regional-scale OGS legend used in Ayer et al. (2004) by C.A. Hawson, P.Geo.

5. Legend colours are derived from those used in Ayer et al. (2004). However, the three dimensional views of the mines require the use of shading and oblique "illumination" to bring about the three dimensional appearance of the deposits on a paper product. Therefore, there are small variations from the colours used in Ayer et al. (2004) to bring about shading.

6. Geographic data, Landsat imagery and geophysical maps were extracted from Ayer et al. (2004).

Modelling Procedure

The initial models were compiled in FracSIS and provided by the donor. Rock units were correlated to the OGS legend (Table 4) by C.A. Hawson, P.Geo., and checked by P. Degagne, P.Geo.

The final FracSIS model compilation includes the surface geology, geophysics, Landsat image and geographic information (roads, rail, rivers and lakes) from Ayer et al. (2004), which was extracted using ArcGIS software.

The Clavos Mine grid coordinate system (CMG) is tied in to NAD27, UTM Zone 17N as follows:

- 514057.0 m Easting = 200.0 m CMG East
- 5384233.0 Northing = -425.0 m CMG North
- 275.0 m Elevation = 1275.0 m
- Rotation = 0 degrees counterclockwise

The Stock Mine grid coordinate system (SMG) is tied in to NAD27, UTM Zone 17N as follows:

- 518349.45 m Easting = 0.0 ft SMG East
- 5377407.02 m Northing = 0.0 ft SMG North
- 308.0 m Elevation = 10000.0 ft
- Rotation = 28.0 degrees counterclockwise

Model validation was carried out in consultation with mine personnel during the compilation process.

Table 4. Original St Andrew Goldfields Ltd. legend supplied by St Andrew Goldfields Ltd., and the legend as correlated to the OGS compilation legend used in Ayer et al. (2004).

St Andrew Goldfields Ltd. Legend		Proposed Legend for 3D Model and Surface Map	
AAO	albite altered rock		Sodium_enrichment
ACG	green carbonate altered rock	1	Ultramafic (to mafic) metavolcanic rocks/intrusions
ACG_fz	green carbonate altered rock	1	Ultramafic (to mafic) metavolcanic rocks/intrusions
ACO	carbonate altered rock	1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Carbonatized
AEC		2	2 Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
AEO		2	2 Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
AFO	fuchsite, carbonate altered rock	1	Ultramafic (to mafic) metavolcanic rocks/intrusions
AHO	chlorite altered rock	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
ALB			Sodium_enrichment
AOO	altered rock-undivided	?	
AQO	silica altered rock	?	siliceous alteration
EOH	End of Hole		
GGC		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Carbonatized
GQBX			siliceous alteration
GYBX		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Carbonatized
HCL			casing
HCO			casing
HCP			casing
HPO	overburden, undivided		
IFD	felsic dyke	11	Porphyry Suite
IFO	felsic intrusive undivided	12	Felsic to Intermediate Intrusive Suite
IID	intermediate dyke	2	2 Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
IID	intermediate intrusive	2	2 Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
IMD	mafic dyke	2	2 Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
IMO	mafic intrusive	10	10 Mafic Intrusive Rocks
IP2	quartz feldspar porphyry	11	Porphyry Suite
IPF	feldspar porphyry	11	Porphyry Suite
IPF_carb		11	Porphyry Suite
IPF_ser		11	Porphyry Suite
IPF_sil		11	Porphyry Suite
IPO	felsic porphyry intrusive	11	Porphyry Suite
IPO/SZ		11	Porphyry Suite
IPO_carb		11	Porphyry Suite
IPQ	quartz porphyry	11	Porphyry Suite
IRO	pegmatite	12	Felsic to Intermediate Intrusive Suite
ISO	syenite intrusive	11	Porphyry Suite
ISP	porphyritic syenite	11	Porphyry Suite
IUO	ultramafic intrusive	9	Ultramafic Intrusive
LDO	late diorite dolerite	15	Mafic Intrusive Rocks: diabase, granophyre
LLB	biotite lamprophyre	20	Lamprophyre

St Andrew Goldfields Ltd. Legend		Proposed Legend for 3D Model and Surface Map	
LLO	lamprophyre	20	Lamprophyre
MCZ		2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
MIV		2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
MIV SZ		2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
OLO			Lost Core
QUO			quartz vein
QVC	quartz carbonate vein		quartz carbonate vein
QVO	quartz vein		quartz vein
S00_1			undefined sedimentary rock
SCO	conglomerate	8	Timiskaming-type metasedimentary rocks
SIA	argillite	7e	Graphite Facies
SIO	fine-sediment undivided	8	Timiskaming-type metasedimentary rocks
SLC	graphitic shale	7e	Graphite Facies
SLO			
SOO	sediment undivided	6	6 Clastic metasedimentary rocks
SSA	arkose	8	8 Timiskaming-type metasedimentary rocks
SSG	greywacke	6b	Wacke
STF	banded iron formation	7a	Iron Formation
VDO	dolerite	15	Mafic Intrusive Rocks
VFO	felsic volcanic, rhyolite, rhyodacite	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
VG			visible gold
VGO	gabbro	10	Mafic Intrusive Rocks
VMF	mafic volcanic-magnetic	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
VMM		2a	massive mafic volcanic
VMM_AHO		2a	massive mafic volcanic
VMM_bl		2a	massive mafic volcanic
VMM_carb		2a	massive mafic volcanic
VMM_ser		2a	massive mafic volcanic
VMM_sil		2a	massive mafic volcanic
VMO	mafic volcanic-basalt andesite	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
VMO_orezone		2a	mafic volcanic
VMO_sch		2a	mafic volcanic
VMO_ser		2a	mafic volcanic
VMO_sil		2a	mafic volcanic
VMP	mafic volcanic pillowed	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
VMP_bl		2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
VMR	mafic volcanic-high Fe basalt	2f	2f High-iron tholeiite
VMT	mafic volcanic-tuffaceous	2f	2f Tuff, lapilli tuff
VMV	mafic volcanic varsolitic	2c	Varsolitic flows
VMV_bl		2c	Varsolitic flows
VMV_ser		2c	Varsolitic flows_serpentized
VMX	mafic breccia	2g	Tuff breccia, pyroclastic breccia
VUK	ultramafic volcanic komatiite	1k	Komatiite

St Andrew Goldfields Ltd. Legend		Proposed Legend for 3D Model and Surface Map	
VUM	massive ultramafic	1	Ultramafic (to mafic) metavolcanic rocks/intrusions
VUM_carb		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Carbonatized
VUM_chl		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Chloritized
VUO	ultramafic volcanic	1	Ultramafic (to mafic) metavolcanic rocks/intrusions
VUO_carb		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Carbonatized
VUO_chl		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Chloritized
VUO_silcarb		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Siliceous_Carbonatized
VUO_tcx		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Carbonatized
VUO_zcx		1	Ultramafic (to mafic) metavolcanic rocks/intrusions_Sheared
VUT	ultramafic tuff	1	Ultramafic (to mafic) metavolcanic rocks/intrusions
ZBO	tectonic breccia		fault
ZCO	cataclastite		fault
ZFO			fault
ZGO	gouge		fault
ZIO			fault
ZSO	schist undivided		fault
ZST	talc chlorite schist	1	Ultramafic (to mafic) metavolcanic rocks/intrusions
ZTZ	fault zone		fault

PORCUPINE JOINT VENTURE: DOME, PAMOUR AND SOUTH TISDALE ANTICLINE MINES

General Information

- Mine site locations: Tisdale, Whitney and Deloro townships (see Ayer and Trowell 1998)
- Deposit type: Archean lode gold
- Property owner: Porcupine Joint Venture (Placer Dome, Inc. and Kinross Gold Corporation)
- Data donor(s): Porcupine Joint Venture (Placer Dome, Inc. and Kinross Gold Corporation), Placer Dome Limited, Ontario Geological Survey (OGS)
- Model supplied by: Porcupine Joint Venture (Placer Dome, Inc. and Kinross Gold Corporation)
- Modifications reviewed by: E. Barr, P.Geo., Porcupine Joint Venture (Placer Dome, Inc. and Kinross Gold Corporation)

Background

The Porcupine Joint Venture (Placer Dome, Inc. and Kinross Gold Corporation), hereafter referred to as PJV, represents a consolidation of lode gold properties in the Timmins camp, a region that, since 1909, has produced more than 65 million ounces of gold. The properties include the Dome, Hoyle Pond and Pamour mines, in addition to a large land package that includes the Nighthawk Lake, Bell Creek,

Hollinger, McIntyre, Hallnor, Preston and Paymaster mines (Figure 5). Placer Dome, Inc. owns 51% of the PJV; the remaining 49% is owned by Kinross Gold Corporation.

Current proven reserves of the PJV are 22.459 million tonnes (Mt) grading 1.3 g/t Au, yielding some 943 000 ounces. Probable reserves stand at 47.086 Mt grading 1.6 g/t Au, yielding an additional 2.496 million ounces (estimates based on 2004 Placer Dome Annual Report and their 51% interest). In 2004, gold production from the PJV totaled some 429 000 ounces.

DOME MINE

The Dome Mine is located in Tisdale Township within the city limits of Timmins, Ontario, approximately 5 km east of the city's core. Underground mining continued uninterrupted from 1910 to 2003; it was shut down at the end of May, 2004. Over its 95-year life, Dome Mine produced 14 537 596 ounces of gold and approximately 2 596 000 ounces of silver, making it the second largest gold producer of the Timmins camp (SRK 2003).

PAMOUR MINE

The Pamour Mine is located in Whitney Township within the City of Timmins, Ontario, approximately 19 km east of the downtown core. Production first began in 1911, but it was not until 1936 that continuous operations commenced. In 1999, the year mining ceased, the operation was purchased by Kinross Gold Corporation. From 1936 to 1997, over 4 million ounces (113 t) of gold was recovered from the Pamour Mine.

SOUTH TISDALE ANTICLINE MINES

The South Tisdale anticline deposits—the Preston, Paymaster, Buffalo-Ankerite and Fuller (Vedron)—are typical Archean lode gold deposits in the Timmins camp. Situated in Tisdale and Deloro townships, adjoining the Dome Mine, they represent both past and potential producers.

The Buffalo-Ankerite Mine yielded some 1 million ounces between 1926 and 1953, while the Paymaster produced some 1.165 million ounces. Vedron Gold Inc., the owner of the Fuller and Buffalo-Ankerite properties, estimates the measured and indicated resource to be 416 462 ounces at the former and 83 106 ounces at the latter. Respective figures for inferred resources are 196 747 ounces and 4659 ounces (Vedron Gold Factsheet).

Deposit Setting

All deposits are typical Archean lode gold deposits spatially associated with the Porcupine–Destor deformation zone. Mineralization is within Tisdale assemblage basalts and ultramafic volcanic rocks, and is also associated with the unconformably overlying Timiskaming metasedimentary rocks.

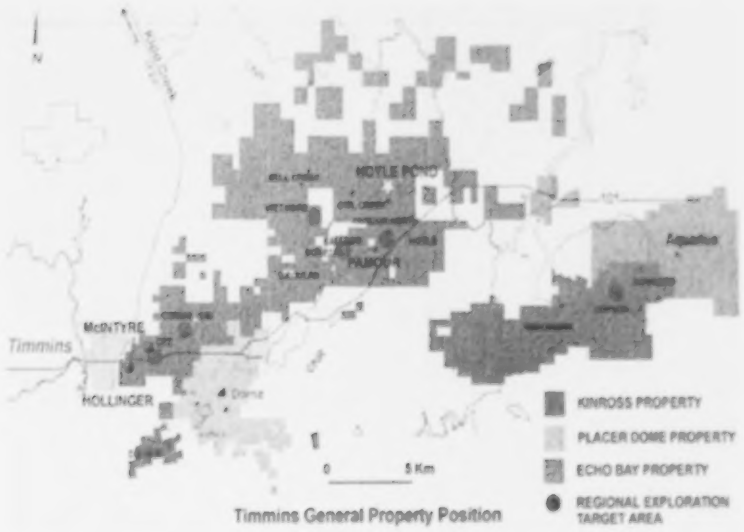

Figure 5. Location map of PJV properties. Dome, Pamour and South Tisdale Anticline properties are included in this report.

Data Donors and Sources

Models in the form of lithologic solids produced in Vulcan™ were provided to the project by the PJV. Added to the lithological solids are vein arrays, stope outlines and mine infrastructure, which were also provided by PJV. No modifications have been made to the materials provided beyond converting the file format to bring them into FracSIS.

Modelling Procedure

The models were constructed by the staff of the Porcupine Joint Venture. MIRARCO brought Vulcan files into FracSIS for distribution. No changes were made to the models donated by PJV. Rock units were correlated to the OGS legend (Table 5) by C.A. Hawson, P.Geo., and checked by E. Barr, P.Geo. The drill holes were created in FracSIS by exporting the collar, survey and lithology data from the provided Access drill-hole database.

The final FracSIS model compilation includes the surface geology, geophysics, Landsat image and geographic information (roads, rail, rivers and lakes) from Ayer et al. (2004), which was extracted using ArcGIS software.

The Dome Mine grid coordinate system (DMG) is tied in to NAD83, UTM Zone 17N as follows:

- 481604.0 m Easting = 2867.792 ft DMG East
- 5367518.0 Northing = 3835.105 ft DMG North
- -150.0 m Elevation = 4650.04 ft
- Rotation = 0 degrees counterclockwise

The Pamour Mine grid coordinate system (PMG) is tied in to NAD83, UTM Zone 17N as follows:

- 491502.6816 m Easting = 4752.3012 m PMG East

Figure 5. Location map of PJV properties. Dome, Pamour and South Tisdale Amulet properties are included in this report.

Data Donors and Sources

Models in the form of lithologic solids produced in Vulcan™ were provided to the project by the PJV. Added to the lithological solids are vein arrays, stope outlines and mine infrastructure, which were also provided by PJV. No modifications have been made to the materials provided beyond converting the file format to bring them into EraeSIS.

Modelling Procedure

The models were constructed by the staff of the Porcupine Joint Venture. MIRARCO brought Vulcan files into EraeSIS for distribution. No changes were made to the models donated by PJV. Rock units were correlated to the OGS legend (Table 5) by C.A. Hawson, P.Geo., and checked by E. Barr, P.Geo. The drill holes were created in EraeSIS by exporting the collar, survey and lithology data from the provided Accecss drill-hole database.

The final EraeSIS model compilation includes the surface geology, geophysics, Landsat image and geographic information (roads, rail, rivers and lakes) from Ayer et al. (2004), which was extracted using ArcGIS software.

The Dome Mine grid coordinate system (DMG) is tied in to NAD83, UTM Zone 17N as follows:

- 481604.0 m Easting = 2867.792 ft DMG East
- 5367518.0 Northing = 3835.105 ft DMG North
- -150.0 m Elevation = 4650.04 ft
- Rotation = 0 degrees counterclockwise

The Pamour Mine grid coordinate system (PMG) is tied in to NAD83, UTM Zone 17N as follows:

- 491502.6816 m Easting = 4752.3012 m PMG East

- 5374416.9917 m Northing = 4185.2106 m PMG North
- 294.5 m Elevation = 3340.0000 m
- Rotation = 0.0 degrees counterclockwise

The South Tisdale grid coordinate system (STG) is tied in to NAD83, UTM Zone 17N as follows:

- 481604.0 m Easting = 2867.792 ft STG East
- 5367518.0 Northing = 3835.105 ft STG North
- -1550.0 m Elevation = 0 ft
- Rotation = 0 degrees counterclockwise

Validation of file transformation was carried out in consultation with mine personnel at each stage of the transformation process.

Table 5. Original PJV legend as supplied by PJV, and the legend as correlated to the OGS compilation legend used in Ayer et al. (2004).

Major Lithology		Propsed PJV Legend for 3D model and Surface Map	
BT	Breakthrough, Void		
CAS	Casing		
FZ	Fault Zone		
GC	Ground Core		
LC	Lost Core		
LR	Lost Rods / Steel		
NL	Not Logged		
OB	Overburden		
RG	Regolith		
SZ	Shear Zone		
UNK	Unknown or Protolith Unidentifiable		
QV	QUARTZ VEIN		
HS	Huronian Supergroup	16	Sedimentary Rocks
TE	Tectonites		
1	Mylonites		
2	Protomylonites		
GN	Migmatites & Gneiss		
1	Biotite Gneiss		
2	Quartzofeldspathic Gn		
3	Orthogneiss		
4	Paragneiss		
5	Pelitic To Semi Pelitic Gneiss		
FP	Felsic Intrusive Rocks	12	Felsic to Intermediate Intrusive Suite
1	Tonalite		12a Tonalite, granodiorite, trondhjemite
2	Granodiorite		12a Tonalite, granodiorite, trondhjemite
3	Granite		12b Granite, quartz monzodiorite, quartz diorite
4	Alkali Feldspar Granite		12b Granite, quartz monzodiorite, quartz diorite
5	Syenite	13	13a Syenite, monzonite, granite
6	Monzonite		13a Syenite, monzonite, granite

Major Lithology		Proposed PJV Legend for 3D model and Surface Map	
7	Pegmatite Dike		13a Syenite, monzonite, granite
8	Aplite Dike		13a Syenite, monzonite, granite
9	Albitite Dike		13a Syenite, monzonite, granite
10	Felsite Dike		13a Syenite, monzonite, granite
11	Quartz-Feldspar Porphyry	11	Porphyry Suite
12	Feldspar Porphyry		11b Quartz and/or feldspar porphyry
13	Quartz Porphyry		11b Quartz and/or feldspar porphyry
14	Porphyry		11a Porphyry
15	Trondhjemite	12	12a Tonalite, granodiorite, trondhjemite
AP	Alkalic Intrusive Rocks	13	Alkalic Intrusive Suite
1	Kimberlite	20	20a Kimberlite
2	Lamprophyre Dike	20	20b Lamprophyre
3	Anorthosite	13	Alkalic Intrusive Suite
4	Anorthosite Gabbro	13	Alkalic Intrusive Suite
5	Nepheline Syenite	13	Alkalic Intrusive Suite
6	Alkalic Syenite	13	Alkalic Intrusive Suite
7	Carbonatite	13	Alkalic Intrusive Suite
8	Fenite	13	Alkalic Intrusive Suite
9	Ijolite	13	Alkalic Intrusive Suite
MP	Mafic Intrusive Rocks	10	Mafic Intrusive Rocks
1	Gabbro	10	10a Diorite, gabbro, metagabbro
2	Norite	10	10e Norite, Hornblendite, Pyroxenite, Amphibolite
3	Hornblendite	9	9b Dunite, Hornblendite
4	Pyroxenite	9	9a Peridotite, pyroxenite
5	Amphibolite	10	Mafic Intrusive Rocks
6	Diorite	10	10a Diorite, gabbro, metagabbro
7	Diabase	15	Diabase Dikes
UP	Ultramafic Intrusive Rocks	9	Ultramafic Intrusive Rocks
1	Peridotite	9	9a Peridotite, pyroxenite
2	Dunite	9	9b Dunite, Hornblendite
3	Hornblendite	9	9b Dunite, Hornblendite
4	Pyroxenite	9	9a Peridotite, pyroxenite
CS	Chemical Metasediments	7	Chemical Metasedimentary Rocks
1	Limestone	7	Chemical Metasedimentary Rocks
2	Dolostone	7	Chemical Metasedimentary Rocks
3	Gypsum	7	Chemical Metasedimentary Rocks
4	Salt	7	Chemical Metasedimentary Rocks
5	Marble	7	Chemical Metasedimentary Rocks
6	Chert	7	7d Silicate facies, chert
IF	Iron Formation	7	7a Iron formation
Cb	Carbonate Facies	7	7f Carbonate facies
Ct	Oxide Facies	7	7b Oxide facies
Si	Silicate Facies	7	7d Silicate facies, chert

Major Lithology		Propsed PJV Legend for 3D model and Surface Map	
Su	Sulphide Facies	7	7c Sulphide facies
SS	Clastic Metasediments		
1	Quartzite		
2	Conglomerate(dark brown)		
3	Arkose		
4	Sandstone		
5	Siltstone		
6	Greywacke/Argillite		
7	Greywacke		
8	Argillite		
9	Slate		
10	Graphitic Argillite		
SP	Clastic Metasediments		
	Porcupine Group	6	Clastic Metasedimentary Rocks
1	Quartzite	6	
2	Conglomerate(light brown)	6	6c Conglomerate
3	Arkose	6	6b Wacke
4	Sandstone	6	6b Wacke
5	Siltstone	6	6d Mudstone, siltstone
6	Greywacke/Argillite	6	6b Wacke
7	Greywacke	6	6b Wacke
8	Argillite	6	6d Mudstone, siltstone
9	Slate	6	6d Mudstone, siltstone
10	Graphitic Argillite	6	6g Graphitic argillite
ST	Clastic Metasediments		
	Timiskaming Group	8	Timiskaming-Type Clastic Metasedimentary Rocks
1	Quartzite	8	
2	Conglomerate(brown)	8	8c Conglomerate
3	Arkose	8	8b Wacke
4	Sandstone	8	8b Wacke
5	Siltstone	8	8d Mudstone, siltstone
6	Greywacke/Argillite	8	8b Wacke
7	Greywacke	8	8b Wacke
8	Argillite	8	8d Mudstone, siltstone
9	Slate	8	8d Mudstone, siltstone
10	Graphitic Argillite	8	8f Graphitic argillite
VF	Felsic Metavolcanics	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
1	Rhyolite	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
2	Rhyodacite	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
3	Dacite	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
VI	Intermediate Metavolcanics	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions
1	Andesite	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions
2	Trachyte	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions

Major Lithology		Propsed PJV Legend for 3D model and Surface Map	
3	Latite	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions
VM	Mafic Metavolcanics	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
1	High Fe Basalts	2	2F High-iron tholeiite
2	High Mg Basalts	2	2M High-magnesium tholeiite
UM	Ultramafic Metavolcanics	1	Ultramafic (to Mafic) Metavolcanic Rocks/Intrusions
1	Basaltic Komatiite	1	1B Basaltic komatiite
2	Peridotitic Komatiite	1	1K Komatiite
FL	Fill in underground void		
1	Classified tailings +/- layers of cement		
2	Paste		
3	Loose rock		
4	Sand and/or gravel		
5	Slag		

PAMOUR MINE GRID COORDINATE SYSTEM

The Pamour Mine grid coordinate system as provide by PJV was defined as geographic projection using NAD27 as horizontal datum; there was no vertical datum included. However, since the mine data has a consistent elevation, it was decided to create a Pamour Mine local coordinate system, to set the vertical reference but keeping the horizontal reference the same as the original one.

Procedures to Make a New Local Coordinate System

1. Import, into FracSIS, Shaft 3 in original mine coordinate system (Pamour_UTM_Coordinate_System)
2. Set the scene's coordinates as Pamour_UTM_Coordinate_System, select the shaft's top center point, record the easting, northing, and height as 4752.3012 m, 4185.2106 m and 3340 m, respectively.
3. Change the scene's coordinate system to NAD83_Zone17, select the same point of the shaft. Record easting and northing as 491502.6816 m, 5374416.9917 m, project the point vertically to the DEM-referenced OGS surface feature of lakes, roads and trails, record the vertical elevation 294.5 m
4. Define a local coordinate system as Pamour Local Elevation Adjusted by joining the two sets of coordinates calculated in points 2 and 3. Since the original coordinate system is NAD83_zone17 projection longitude centre, there is no rotation between the original mine coordinate system and NAD83_Zone17.

NEWMONT MINING CORP.: HOLLOWAY MINE

General Information

- Mine site location: Holloway Township (see Ayer et al. 1999)
- Deposit type: Archean lode gold
- Property owner: Newmont Mining Corporation and Teddy Bear Valley Mines, Ltd.
- Data donor(s): Newmont Mining Corporation and Ontario Geological Survey (OGS)
- Model built by: L. Cotesta, with assistance from P. Vasak, C.A. Hawson, P.Geo., J. Whitmore, G. Wang, F.D. Prévost, A. van Wageningen; and B. Anderson and G. Yang (BLAZE I.T.)
- Checked by: R. Kusins (Newmont Mining Corporation), H. Poulsen, P.Geo., and P.C. Thurston P.Geo. (MERC)

Background

The Holloway Mine is located in Holloway Township, 60 km north of Kirkland Lake, Ontario. It is 84.65% owned by Newmont Mining Corporation, with the balance owned by Teddy Bear Valley Mines. From start-up in 1996 to the end of 2003, the mine produced in excess of 600 000 ounces of gold. Proven and probable reserves as of December 31, 2003 stood at 360 000 ounces (Newmont Mining Corp., 2004), putting this mine into the ranks of >1 million ounces.

Deposit Setting

The Holloway Mine is a typical Archean lode gold deposit lying adjacent to the Porcupine–Destor deformation zone. This mine lies within rocks of the 2711-2718 Ma Kidd–Munro assemblage in contact with the circa 2680 Ma Timiskaming assemblage. Host rocks of the deposit are ultramafic and mafic metavolcanic rocks of the Kidd–Munro assemblage and minor interflow argillites. The deposit trends east for about 800 m and dips about 50 to 70° to the south. It extends vertically from 200 m below surface to 800 m below surface and is open at depth. The main zone, the so-called Lightning Zone, is variable in grade, width and dip, and is somewhat discontinuous. The mineralized zone is a difficult exploration target in that parts of the zone have a relatively shallow dip, complicating drill data interpretation. The gold values occur within massive grey silicified and albitized zones with 5 to 10% disseminated pyrite.

Data Donors and Sources

LOCAL GEOLOGICAL SURFACE MAP

A surface geology map was provided by Newmont Mining Corporation in MapInfo™ format by MapInfo Corporation (www.mapinfo.com).

GEOLOGICAL PLANS, SECTIONS AND MINE LEVELS

Initially, all data was provided in AutoCAD (www.autodesk.com) format that was created with the use of an add-on called Promine™ (www.promine.com). The following relevant mine codes/descriptions were identified within the datasets and used for subsequent modelling tasks:

From the Holloway Plans files:

- WWAC – ultra mafic contact
- OAOR – mineralization (ore outlines from level plans)
- OFTH – chip samples and test holes
- WWSS – structure, joints, contacts and structural symbols
- HACT – drill-hole pierce points
- OMGR – round muck grade
- WTXT – geological mapping text

From the Holloway Sections files:

- SINT – interpreted ore polygons
- DACT – actual development drifts
- SSTR – any geological contact, can be sedimentary/volcanic, massive/pillowed, etc.
- SULT – ultramafic contact
- S3DY – mine 3D breccia contact

Note that data existed for these codes, however, interpretations were not fully complete and, hence, some of the data was not used.

DRILL-HOLE DATA

Newmont Mining Corporation provided MIRARCO with a Gemcom (www.gemcomsoftware.com) drill-hole database stored in Access format. This database contained 4502 drill holes with header, survey, lithology and assay data. There were 2160 unique rock type codes in the drill logs provided. These codes were simplified and correlated to generalized OGS nomenclature using the legends provided by Newmont Mining Corporation (see "Legend Nomenclature" section, below).

Modelling Procedure

DATA IMPORT AND MODELLING CONVENTIONS

1. Surface Geology
    a. The local MapInfo data was directly imported into FracSIS. Original mine geology nomenclature was also imported. The original legend codes were later linked to OGS legend colours (*see* "Legend Nomenclature" section, below).
2. Drilling
    a. A Gemcom database (Access format) was deconstructed into the following ASCII files:
        i. Collar information (surface location X, Y, Z)
        ii. Survey (depth, down-hole dip and azimuth)
        iii. Lithology (from, to, LithoCode)
        iv. Assay files (from, to, Au (grams per tonne))

b. These files were then imported into gOcad to help with the 3D interpretation of the 3D deposit model.

3. Mine levels
    a. Note: Due to the geological nature of the project, the mine infrastructure is approximate at best and is to be used for visualization purposes only.
    b. The 3D mine infrastructure was directly imported into FracSIS via .dxf importers.
4. Mineralization zone construction
    a. Data from plans and sections were extracted from AutoCAD and imported into gOcad.
    b. Curves representing plans and sections of the mineralized zones were properly georeferenced and subsequently portioned into several regions based on geometric complexity (i.e., folding) to facilitate the 3D modelling process.
    c. Once portioned, individual regions were used for solids modelling and several solids representing "mineralized zones" were created. These were later merged to comprise one single "envelope" to represent the mineralized zones of the deposit (Figure 6).
5. 2D geological contact construction
    a. Data from plans and sections were extracted from AutoCAD and imported into gOcad.
    b. Curves representing plans and sections of the geological contacts were properly georeferenced and cleaned up.
    c. The polylines were then used to build the 3D surfaces (Figure 6). The following contacts were modelled:
        i. Ultramafic contact (regional scale)
        ii. Far East Mafic Volcanic contact (partial regional scale)
        iii. Mafic Volcanic contact (partial regional scale)
        iv. Sedimentary contact (partial regional scale)

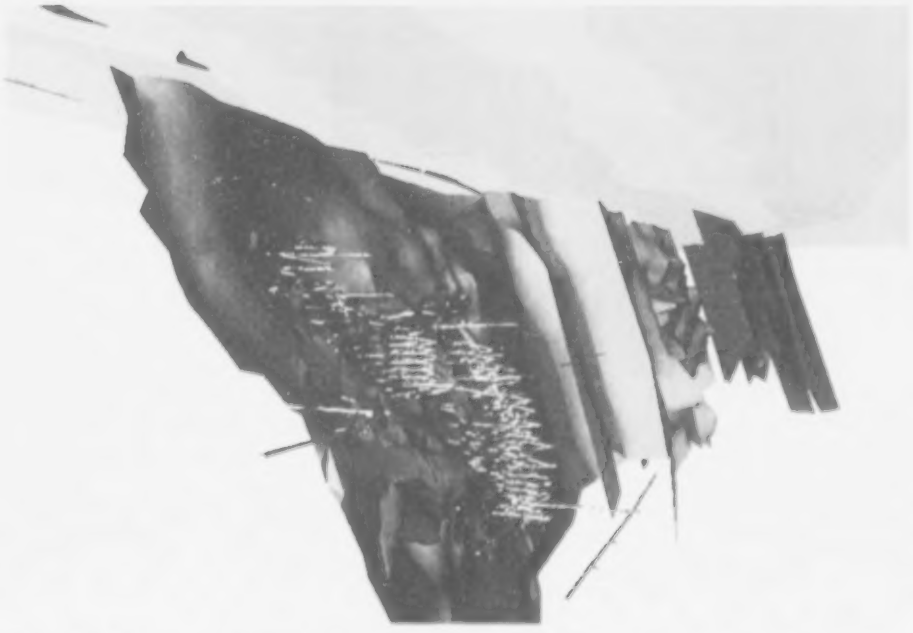

Figure 6. Holloway Mine deposit model hanging from Newmont Mining Corporation geological map. Deposit model shows mine workings, mineralized zone, ultramafic metavolcanic contact, mafic metavolcanic contacts and the clastic metasedimentary contacts. (See chart in back pocket for colour version of this figure.)

DATA VALIDATION

Data validation was ongoing throughout the construction of the model by closely working with R. Kusins of Newmont Mining Corporation, the main data and modelling contact person for the Holloway Mine. Throughout the modelling process, a number of Raider3D models were provided to Newmont Mining Corporation in order for them to carry out "remote" validation. Also, a Virtual Reality session was held in Timmins with various interdisciplinary experts present to perform final data validation for the deposit model.

Legend Nomenclature

For initial model construction, the mine's legend nomenclature was utilized. This nomenclature was later correlated to the OGS legend used in Ayer et al. (2004). Correlation to the OGS compilation legend was carried out by C.A. Hawson, P.Geo. and approved by R. Kusins (Newmont Mining Corporation). Table 6 shows the original various legends used by the mine on maps and in drill holes and the resulting correlation to the OGS legend used in Ayer et al. (2004).

Table 6. Various Holloway Mine geology nomenclatures correlated with the legend used by OGS in Ayer et al. (2004).

Exploration		Mine		Correlation to OGS legend (final Holloway Legend used)	
Rock code	Description	Rock Code	Description	Rock Code	Description
8U	Diabase	8u	Diabase	15	15a Matachewan (2452 Ma) (NW)
7U	Felsic to Intermediate Intrusive	6u			
7G	Granite	6u	Unsubdivided	12	Felsic to Intermediate Intrusive Suite
7GD	Granodiorite, Quartz Monzonite	6u	Unsubdivided	12	Felsic to Intermediate Intrusive Suite
7T	Tonalite	6u	Unsubdivided	12	Felsic to Intermediate Intrusive Suite
7S	Syenite	6u	Unsubdivided	12	Felsic to Intermediate Intrusive Suite
7M	Monzonite	6u	Unsubdivided	12	Felsic to Intermediate Intrusive Suite
7FP	Feldspar Porphyry	6a	Feldspar Porphyry	11	11b Quartz and/or feldspar porphyry
7QFP	Quartz/Feldspar Porphyry	6b	Quartz/Feldspar Porphyry	11	11b Quartz and/or feldspar porphyry
7PA	Pegmatite	6u	Unsubdivided	11	Porphyry Suite
7A	Aplite	6u	Unsubdivided	11	Porphyry Suite
7F	Felsite	6c	Felsite	11	Porphyry Suite
6U	Mafic to Ultramafic Intrusive	5u	Mafic to Ultramafic Intrusive	9	Ultramafic Intrusive Rocks
6D	Diorite, Trondhjemite	5u	Unsubdivided	10	10a Diorite, gabbro, melagabbro
6G	Gabbro	5b	Gabbro	10	10a Diorite, gabbro, melagabbro
6A	Anorthosite	5u	Unsubdivided	10	10c Anorthositic gabbro, leucogabbro
6P	Peridotite, Pyroxenite	5u	Unsubdivided	9	Ultramafic Intrusive Rocks
6L	Lamprophyre	5a	Lamprophyre	20	Kimberlite, Lamprophyre or 13_Alkalic_Intrusive_Suite
5U	Clastic Sediments	1u	Sediments		
5AR	Argillite	1b	Greywacke / Argillite	8	8b Wacke
5ARGF	Graphitic Argillite	1d	Carbonaceous Argillite	8	8d Mudstone, siltstone
5GW	Greywacke	1b	Greywacke / Argillite	8	8b Wacke
5CG	Conglomerate	1f	Non-jasper Conglomerate	8c	8c Timiskaming Conglomerate

Exploration		Mine		Correlation to OGS legend (final Holloway Legend used)	
Rock code	Description	Rock Code	Description	Rock Code	Description
5CGT	Timiskaming Conglomerate	1a-cg	Timiskaming Conglomerate	8c	8c Timiskaming Conglomerate_Jasper_bearing
5SS	Sandstone	1b	Greywacke / Argillite	8	8b Wacke
5ST	Siltstone	1b	Greywacke / Argillite	8	8b Wacke
5Q	Quartzite	1u	Unsubdivided	8	Timiskaming-Type Clastic Metasedimentary Rocks
5A	Arkose	1b	Greywacke / Argillite	8	8b Wacke
4U	Chemical Sediments	7u	Chemical Sediments		
4IF	Iron Formation	7a	Iron Formation	7	7a Iron formation
4IFS	Sulphide Facies	7a	Iron Formation	7	7a Iron formation_Sulphide
4IFC	Silicate Facies	7a	Iron Formation	7	7a Iron formation_Silicate
4IFO	Oxide Facies	7a	Iron Formation	7	7a Iron formation_Oxide
4C	Chert	7c	Chert	7d	7d Silicate facies, chert
4GF	Graphite	7b	Graphitic	7e	7e Graphite facies
3U	Felsic To Intermediate Volcanics	6v	Felsic to Intermediate Volcanics		
3R	Rhyolite	6r	Rhyolite	3	Intermediate (to Felsic) Metavolcanic Rocks Intrusions
3D	Dacite	6d	Dacite	3	Intermediate (to Felsic) Metavolcanic Rocks Intrusions
3A	Andesite	6v	Unsubdivided	3	Intermediate (to Felsic) Metavolcanic Rocks Intrusions
3T	Trachyte	6v	Unsubdivided	5	Alkalic and Subalkalic Metavolcanic Rocks Intrusions_Timiskaming Type
2U	Mafic Volcanics	3u	Mafic Volcanics		
2MS	Massive	3a	Massive	2	2a Massive flows
2P	Pillowed	3b	Pillowed	2	2b Pillowed flows
2FB	Mafic Flow Breccia	3b-bx	Brecciated	2	2g Tuff breccia, pyroclastic breccia
2HY	Mafic Hyaloclastite	3c	Hyaloclastite	2	2d Hyaloclastite, flow breccia
2VAR	Varioliti	3VR	>50% varioles	2	2c Variolitic flows
2PO8	Porphyritic	3a-por	Porphyritic	2	Mafic (to Intermediate) Metavolcanic Rocks Intrusions
5D		3d	Volcaniclastic	2	Mafic (to Intermediate) Metavolcanic Rocks Intrusions
1U	Ultramafic Volcanics	4u	Ultramafic Volcanics		
1TC	Talc-Chlorite Altered	4a	Talc chl serp carb facies	1	Ultramafic (to Mafic) Metavolcanic Rocks Intrusions_talcose
1GCB	Green-Carbonate Altered	4c	Fuchsite ank qtz facies	1	Ultramafic (to Mafic) Metavolcanic Rocks Intrusions_carbonatized
1BK	Basaltic Komatiite	4u	Unsubdivided	1	Ultramafic (to Mafic) Metavolcanic Rocks Intrusions
		4d	Fragmental	1	Ultramafic (to Mafic) Metavolcanic Rocks Intrusions

Note that all relevant FracSIS legend files are stored in the project folder as property files (*.fvp) within the "Property files (fvp)" subfolder. Listed below are the relevant property files related to legends.

- GH_geology_OGS_Legend_Colours.fvp – final legend used to apply OGS colouring to the "GH_geology" local geological surface map. This property file is to be applied to the "Legend_code" field.
- OGS_Rocktype_Legend_RGB.fvp – OGS legend to be applied to the regional OGS "cut-outs" for the ROCK_TYPE field.

COORDINATE SYSTEM TRANSFORMATIONS

All data was initially received in the Holloway Mine grid as defined by Newmont Mining Corporation. This mine grid was defined and stored in the FracSIS database so that a coordinate transform could be applied within the FracSIS software. The coordinate system file was also stored in the project folder in the "Coordinate System Definitions (csd)" subfolder as a file called "Holloway Mine Grid.csd". This definition may be used/imported in other projects (i.e., gap analysis for Holloway and Holt McDermott). The local grid system is defined as follows:

Target projected coordinate system: NAD27, UTM Zone 17N

- Transform from local point:
  - Easting: 8175.33 m
  - Northing: 4508.7 m
  - Height: 3288.34 m
- To projected point:
  - Easting: 594990.9490 m
  - Northing: 5374877.7030 m
  - Height: 288.34 m
- No rotation

Scope for Further Improvement

As with all modelling, there is always room for improvement, and interpretations are constantly evolving as a result of data integration and 3D modelling in general. For the Holloway deposit, the 3D interpretation was made based on an initial interpretation that was done in 2D from projected drill holes onto plans and sections. The initial 2D interpretation could be further constrained by the 3D drilling and newly unified legend.

A partial regional model has been constructed. However, it would be possible to construct a more complete regional contact model of the various lithological units from existing drill-hole information (Figure 7). It would also be of great interest to construct a 3D fault network model to enhance exploration activities.

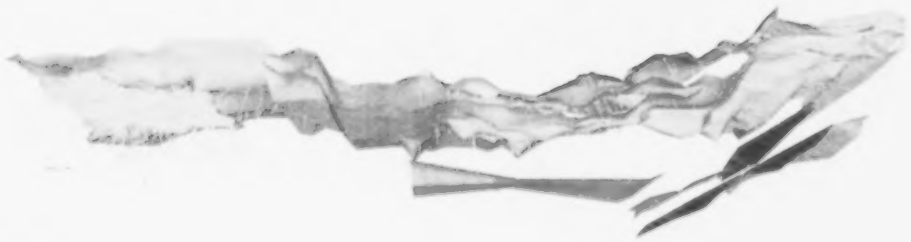

Figure 7. Plan view of 3D Holloway Mine contacts with drill holes coloured by down-hole geology. 3D contacts are not fully modelled across the local scale, however, the down-hole geology clearly shows the extent of the clastic metasedimentary contacts and the mafic metavolcanic contacts in the western portion of the model. (See chart in back pocket for colour version of this figure.)

NEWMONT MINING CORP.: HOLT-MCDERMOTT MINE

General Information

- Mine site location: Holloway Township (see Ayer et al. 1999)
- Deposit type: Archean lode gold
- Property owner: Newmont Mining Corporation
- Data donor(s): Newmont Mining Corporation and Ontario Geological Survey (OGS)
- Model built by: L. Cotesta, with assistance from P. Vasak, C.A. Hawson, P.Geo., J. Whitmore, G. Wang, F.D. Prévost, and R. Anderson (BLAZE I.T.)
- Checked by: R. Kusins (Newmont Mining Corporation) and P.C. Thurston, P.Geo. (MERC)

Background

The Holt-McDermott Mine is located in Holloway Township, 50 km northeast of Kirkland Lake, Ontario, adjacent to the Holloway Mine lying just to the north. Production began in 1988 and ceased in October, 2004, at which time the property and associated assets were acquired from Barrick Gold Corporation by Newmont Mining Corporation. Over its life, the mine produced some 1.3 million ounces of gold.

Deposit Setting

The Holt-McDermott Mine is a typical Archean lode gold deposit lying adjacent to the Porcupine–Destor deformation zone. This mine lies within rocks of the 2711-2718 Ma Kidd–Munro assemblage in contact with the circa 2680 Ma Timiskaming assemblage. Host rocks of the deposit are ultramafic and mafic metavolcanic rocks of the Kidd–Munro assemblage and minor interflow argillites.

Data Donors and Sources

LOCAL GEOLOGICAL SURFACE MAP

A surface geological map was provided by Newmont in MapInfo format (www.mapinfo.com). This is the same map that was used for the Holloway Mine deposit.

GEOLOGICAL SECTIONS AND MINE INFRASTRUCTURE SECTIONS

Initially, all data was provided as an ASCII flat file exported from a mining software platform called Medsystem™. This package is no longer supported by its original developer (Mintec Inc. website: www.mintec.com). It was necessary to create a custom program to extract pertinent section information from the file. This process was extremely tedious and challenging. The extraction, while not perfect, provided sufficient section information to construct the mineralized zones, various contacts (partial), faults and mine infrastructure (development and stopes). The following relevant mine codes/descriptions were identified within the datasets and used for subsequent modelling tasks:

- 001 to 051 - Stopes
- 101 - Ore Interpretation
- 103 and 104 - Stopes
- 201 - Syenite (although there appears to be some alteration lines on some sections)
- 301 - Diabase and possibly Mafic Intrusives
- 401 - Alteration envelopes
- 501 - Faults (Ghostmount and McKenna)
- 801 - Mine Infrastructure (Stopes and Levels)

Note that data existed for these codes, however, interpretations were not fully complete and, hence, some of the data was not used.

DRILL-HOLE DATA

Newmont provided MIRARCO with a Gemcom (www.gemcomsoftware.com) drill-hole database stored in Access format. This database contained 5510 drill holes with header, survey, lithology and assay data. There were 1172 unique rock type codes in the drill logs provided. These codes were simplified and correlated to generalized OGS nomenclature using the legends provided by Newmont (see "Legend Nomenclature" section, below).

Modelling Procedure

DATA IMPORT AND MODELLING CONVENTIONS

1. Surface Geology
    a. The local MapInfo was directly imported into FracSIS. Original mine geology nomenclature was used initially. The original legend codes were later linked to OGS legend colours (see "Legend Nomenclature" section, below).
2. Drilling
    a. A Gemcom database (Access format) was deconstructed into the following ASCII files:
        i. Collar information (surface location X, Y, Z)
        ii. Survey (depth, downhole dip and azimuth)
        iii. Lithology (from, to, LithoCode)
        iv. Assay files (from, to, Au in grams per tonne)
    b. These files were then imported into gOcad to help with the 3D interpretation of the 3D deposit model.
3. Mine levels and stopes
    a. NOTE: Due to the geological nature of the project, the mine infrastructure is approximate at best and is to be used for visualization purposes only.
    b. Some mine infrastructure was already provided in a 3D format and was directly imported into FracSIS via .dxf importers.
    c. Remaining parts of the mine were constructed from cross-sections that were extracted from the Medsystem file. This work was done in the gOcad modelling environment and later exported to FracSIS via gOcad importers.
    d. Stope section information was also extracted from Medsystem's database. It appeared as though the sections were spaced approximately 12.5 m apart. For this reason, the sections were extruded laterally by 12.5 m to allow for 3D solids of the stopes to be quickly constructed. The end result was approximate but still quite useful for visualization purposes.
4. Mineralization zone construction
    a. Sections were extracted from Medsystem's database and imported into gOcad.
    b. Curves representing sections of the mineralized zones were properly georeferenced and subsequently portioned into several regions based on geometry complexity (i.e., folding) to facilitate the 3D modelling process.
    c. Once portioned, individual regions were used for solids modelling, and several solids representing "ore zones" were created. These were later merged to comprise one single "envelope" to represent the mineralization zones of the deposit (Figure 8).
5. 3D geological faults and contacts construction
    a. Sections were extracted from Medsystem's database and imported into gOcad.
    b. Curves representing sections of the geological faults and contacts were properly georeferenced and cleaned up. Most of the geological contacts appeared to be incomplete and due to time constraints, these contacts were not modelled.
    c. The relevant polylines were then used to build the 3D surfaces (Figure 8). The following fault and contact surfaces were modelled:
        i. Contact_501_Ghostmount_Fault
        ii. Contact_501_McKenna_Fault
        iii. Contact_MEDS201_Syenite_Partial
        iv. Contact_MEDS_401_Alteration_Zone_Partial

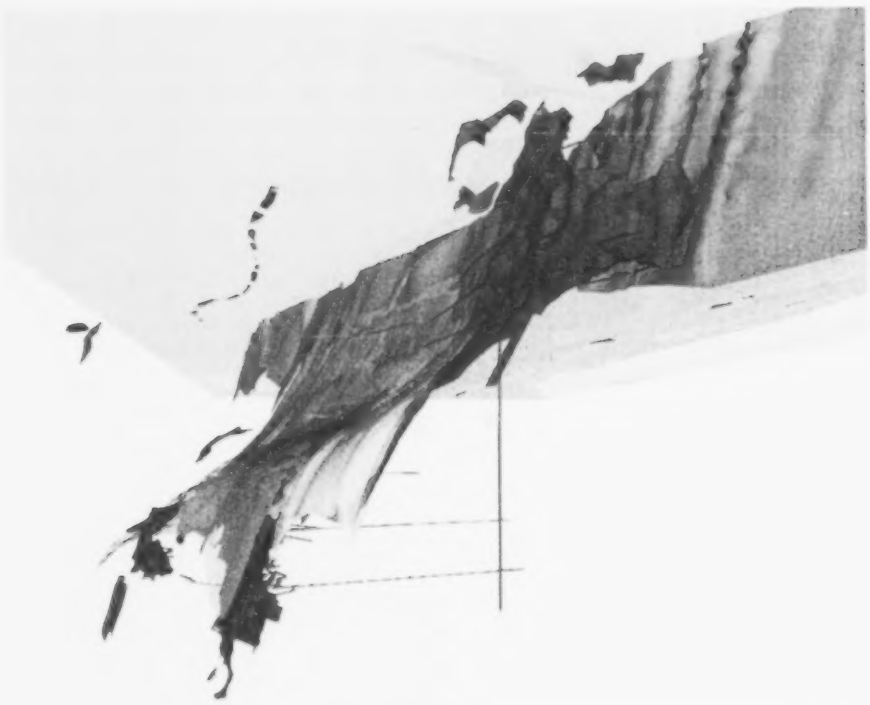

Figure 8. 3D view looking approximately northwest to the Holt-McDermott deposit model showing mine infrastructure, surface geology, mineralized zones, the McKenna fault and a partial syenite contact. (See chart in back pocket for colour version of this figure.)

DATA VALIDATION

Data validation was ongoing throughout the construction of the model by closely working with R. Kusins, P.Geo., of Newmont Mining Corporation, the main data and modelling contact person for the Holt-McDermott Mine. Throughout the modelling process, a number of Raider3D models were provided to Newmont in order for them to carry out "remote" validation.

LEGEND NOMENCLATURE

The task of legend simplification was undertaken by carefully examining the drill logs. We were successful in bringing the number of lithologic codes from 1172 down to 187 by combining a number of historical mine geology legends. Finally, the legend was broken up into 6 parts: Litho (87 codes); Structure (22 codes); Overburden (4 codes); Alteration (57 codes); Drilling related (7 codes); and Uncertain (9 codes). The final legends may be seen below in Table 7.

For initial model construction, the mine's nomenclature was utilized. This nomenclature was later correlated to the OGS legend used in Ayer et al. (2004). Correlation to the OGS compilation legend was carried out by C.A. Hawson, P.Geo., and approved by R. Kusins (Newmont Mining Corporation). Table 7

shows the original legend used by the mine on maps and in drill holes and the resulting correlation to the OGS legend used in Ayer et al. (2004).

Table 7. Various Holt-McDermott Mine geology nomenclatures correlated with the legend used by OGS in Ayer et al. (2004).

Holt_McDermott Code	Holt_McDermott Lithology Description	OGS code	OGS Description	Code Type
Lithological Code				
CABX	Chloritic fault breccia	1	Ultramafic (to Mafic) Metavolcanic Rocks/Intrusions	Litho
V13	Ultramafic Flow	1	Ultramafic (to Mafic) Metavolcanic Rocks/Intrusions	Litho
CCS	Chlorite-Carbonate Schist	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
CCSM	Chlorite-Carbonate Schist	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
FOB	Foliated Basalt	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
TSB	Transitionally Silicified Basalt	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
V7	Mafic volcanics (>60%)	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
V7L	Mafic volcanics (>60%)	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
V7M	High Mag Basalt	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
VSB	Variably Silicified Basalt	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
VSBM	Variably Silicified Basalt	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
V1	Intermediate to felsic volcanics (>60%)	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V10	Agglomerate	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V10	Agglomerate	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V1V7	Mixture of V1 and V7	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V1V9	Mixture of V1 and V9	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V2	Rhyolite	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V6	Andesite	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V8	Pyroclastic	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
V9	Tuff	3	Intermediate (to Felsic) Metavolcanic Rocks/Intrusions	Litho
CHBX	Cherty breccia	7	7d Silicate Facies	Litho
CHGS	Cherty graphitic sediment	7	7d Silicate Facies, Chert	Litho
CHS	Cherty sediment	7	7d Silicate Facies, Chert	Litho
CHSD	Cherty sediment	7	7d Silicate Facies	Litho
CHSD	Cherty Sediments	7	7d Silicate Facies, Chert	Litho
CHV7	Cherty sediment / Volcanic	7	7d Silicate Facies, Chert	Litho
CLGS	Graphitic sediment	7	7e Graphite Facies	Litho
CTZ	Graphitic Zone	7	7e Graphite Facies	Litho

Holt_McDermott Code	Holt_McDermott Lithology Description	OGS code	OGS Description	Code Type
F2	Sulphide facies	7	7e Sulphide Facies	Litho
F3	Oxide facies	7	7b Oxide Facies	Litho
F4	Carbonate facies	7	7f Carbonate Facies	Litho
FZGS	Fault Zone - Graphitic	7	7e Graphite Facies	Litho
GBX	Graphitic breccia	7	7e Graphite Facies	Litho
GS	Graphitic sediment	7	7e Graphite Facies	Litho
GSBX	Graphitic sediment	7	7e Graphite Facies	Litho
GSCH	Graphitic sediment	7	7e Graphite Facies	Litho
GSF	Graphitic sediment	7	7e Graphite Facies	Litho
GSS3	Graphitic sediment	7	7e Graphite Facies	Litho
GSSD	Graphitic sediment	7	7e Graphite Facies	Litho
GST	Graphitic Zone	7	7e Graphite Facies	Litho
GSV1	Graphitic sediment / Volcanic	7	7e Graphite Facies	Litho
GSV7	Graphitic sediment / Volcanic	7	7e Graphite Facies	Litho
SGBX	Silicified graphitic breccia	7	7e Graphite Facies, Silicified	Litho
SGS	Graphitic Sediment	7	7e Graphite Facies	Litho
S1	Conglomerate	8	Timiskaming Conglomerate	Litho
S2	Arkose	8	Timiskaming Arkose	Litho
S2S1	Arkose / Conglomerate	8	Timiskaming Arkose Conglomerate	Litho
S3	Greywacke	8	Timiskaming Greywacke	Litho
S4	Argillite	8	Timiskaming Argillite	Litho
S5	Quartzite	8	Timiskaming Quartzite	Litho
4H	Hornblendite	9	Ultramafic Intrusive Rocks	Litho
4P	Peridotite	9	Ultramafic Intrusive Rocks	Litho
4U	Ultramafic Intrusive	9	Ultramafic Intrusive Rocks	Litho
4Y	Pyroxenite	9	Ultramafic Intrusive Rocks	Litho
2D	Diorite	10	Mafic Intrusive Rocks	Litho
3G	Gabbroic intrusive	10	10a Diorite, Gabbro, Melagabbro	Litho
MI	Mafic intrusive (not diabase)	10	Mafic Intrusive Rocks	Litho
MIF	Mafic intrusive (not diabase)	10	Mafic Intrusive Rocks	Litho
MIM	Mafic intrusive (not diabase)	10	Mafic Intrusive Rocks	Litho
II	Intermediate intrusive	12	Felsic to Intermediate Intrusive Suite	Litho
1D	Granodiorite	13	Alkalic Intrusive Suite	Litho
1G	Granite	13	Alkalic Intrusive Suite	Litho
1M	Monzonite	13	Alkalic Intrusive Suite	Litho
1A	Syenite	13	Alkalic Intrusive Suite	Litho
1S	Syenite	13	Alkalic Intrusive Suite	Litho
1S3D	Syenite	13	Alkalic Intrusive Suite	Litho
1SBT	Syenite	13	Alkalic Intrusive Suite	Litho
1SM	Syenite	13	Alkalic Intrusive Suite	Litho
1SMR	Syenite	13	Alkalic Intrusive Suite	Litho
1SO	Syenite	13	Alkalic Intrusive Suite	Litho
1SOT	Syenite	13	Alkalic Intrusive Suite	Litho

Holt_McDermott Code	Holt_McDermott Lithology Description	OGS code	OGS Description	Code Type
ISP	Syenite	13	Alkalic Intrusive Suite	Litho
ISPM	Syenite	13	Alkalic Intrusive Suite	Litho
ISPR	Syenite	13	Alkalic Intrusive Suite	Litho
ISPT	Syenite	13	Alkalic Intrusive Suite	Litho
ISR	Syenite	13	Alkalic Intrusive Suite	Litho
ISRM	Syenite	13	Alkalic Intrusive Suite	Litho
ISRP	Syenite	13	Alkalic Intrusive Suite	Litho
ISRT	Syenite	13	Alkalic Intrusive Suite	Litho
IST	Syenite	13	Alkalic Intrusive Suite	Litho
ISTP	Syenite	13	Alkalic Intrusive Suite	Litho
IS	Syenite	13	Alkalic Intrusive Suite	Litho
ISV7	Syenite / Volcanic	13_2	Alkalic Intrusive Suite_Mafic (to Intermediate) Metavolcanic Rocks/Intrusions	Litho
3D	Diabase	15	Diabase Dyke	Litho
3DM	Diabase	15	Diabase Dyke	Litho
3DME	Diabase	15	Diabase Dyke	Litho
3L	Lamprophyre	20	Lamprophyre	Litho
Structural Legend				
FAC	Fault Contact		Fault	Structure
FAZ	Fault Zone		Fault	Structure
FI	Fault Zone		Fault	Structure
FLT	Fault Zone		Fault	Structure
FP	Fault Contact		Fault	Structure
FTZ	Fault Zone		Fault	Structure
FZ	Fault Zone		Fault	Structure
FZHW	Hangingwall Fault Zone		Fault	Structure
GMF	Ghostmount Fault		Fault	Structure
GMFP	Ghostmount Fault		Fault	Structure
HWFZ	Hangingwall Fault Zone		Fault	Structure
IMFP	Imperial Fault Plane		Fault	Structure
LITH	Fault Zone		Fault	Structure
M1	Schist		Fault	Structure
M10	Mylonite		Fault	Structure
MCFP	McKenna Fault Plane		Fault	Structure
MCFZ	McKenna Fault Zone		Fault	Structure
MCKP	McKenna Fault Plane		Fault	Structure
RZ	Fault Zone		Fault	Structure
SHRZ	Shear Zone		Shear	Structure
SHZ	Shear Zone		Shear	Structure
SZ	Shear Zone		Shear	Structure
Overburden Legend				
BOUL	Overburden - boulders		Overburden	OB
CLAY	Overburden - clay		Overburden	OB

Holt_McDermott Code	Holt_McDermott Lithology Description	OGS code	OGS Description	Code Type
GRAV	Overburden - Gravel		Overburden	OB
OB	Overburden		Overburden	OB
Alteration Legend				
BX	Breccia			alt
BXFZ	Breccia Fault Zone			alt
BXQZ	Brecciated Quartz Zone			alt
BXZ	Brecciated Zone			alt
CCV	Carbonate Veins			alt
CGBX	Cherty Graphitic Breccia			alt
CMBX	Breccia Zone			alt
CMSZ	Carbonaceous Main Silicified Zone			alt
CQBX	Breccia			alt
CQV	Carbonate-quartz Vein			alt
CQVG	Carbonate-quartz Vein			alt
CV	Carbonate Vein			alt
GMMZ	Ghostmount Mineralized Zone			alt
GMNZ	Ghostmount North Mineralized Zone			alt
GTSZ	Carbonaceous Transitionally Silicified Zone			alt
HWMZ	Hanging Wall Mineralized Zone			Alt
HWSZ	Hanging Wall Silicified Zone			alt
LMZ	Lower Mineralized Zone			alt
LSZ	Lower Silicified Zone			alt
MMZ	Main Mineralized Zone			alt
MSZ	Main Silicified Zone			alt
MZ	Mineralizied Zone			alt
PY	Pyrite			alt
QBX	Quartz Breccia			alt
QCBX	Quartz-Carbonate Breccia			alt
QCV	Quartz Carbonate Veins			alt
QCVZ	Quartz Carbonate Veins			alt
QTVZ	Quartz Veins			alt
QTZ	Quartz Veins			alt
QV	Quartz Veins			alt
QVBX	Quartz Breccia			alt
QVT	Quartz Veins			alt
QVV7	Quartz Veins / Volcanic			alt
QVZ	Quartz Veins			alt
QZBX	Quartz Breccia			alt
QZV	Quartz Veins			alt
QZVN	Quartz Veins			alt
S10	10% Silicified			alt
S100	100% Silicified			alt
S101	10% Silicified			alt

Holt_McDermott Code	Holt_McDermott Lithology Description	OGS code	OGS Description	Code Type
S102	10% Silicified			alt
S10M	10% Silicified			alt
S20	20% Silicified			alt
S30	30% Silicified			alt
S40	40% Silicified			alt
S50	50% Silicified			alt
S60	60% Silicified			alt
S70	70% Silicified			alt
S80	80% Silicified			alt
S90	90% Silicified			alt
TS	Transitionally Silicified Zone			alt
TSZ	Transitionally Silicified Zone			alt
UMZ	Upper Mineralized Zone			alt
USZ	Upper Silicified Zone			alt
VSS	Variably Silicified Sediment			alt
VSZ	Variably Silicified Zone			alt
VSZM	Variably Silicified Zone			alt
Drilling related				
CAS	Casing			Drilling
CASE	Casing			Drilling
CASI	Casing			Drilling
CASS	Casing			Drilling
GC	Ground Core			Drilling
LC	Lost core			Drilling
LOST	Lost core			Drilling
Uncertain Codes				
CLZ	Card Lake Zone			unsure
M5	Migmatite		Deformed Intrusive	unsure
M7	Gniess		Deformed Intrusive	unsure
M8	Amphibolite		Deformed Intrusive	unsure
SCH	Greenschist			unsure
SEDS	Sediments unknown?			unsure
UNK	lithology uncertain			unsure
DINT	Deformed Intrusive			unsure
3DV7	Diabase / Volcanic			unsure

Note that all relevant FracSIS legend files are stored in the project folder as property files (*.fvp) within the "Property files (fvp)" subfolder. Here is a list of the relevant property files related to legends:

- GH_geology_OGS_Legend_Colours.fvp – final legend used to apply OGS colouring to the "GH_geology" local geological surface map. This property file is to be applied to the "Legend_code" field.

- OGS_Rocktype_Legend_RGB.fvp – OGS legend to be applied to the regional OGS "cut-outs" for the ROCK_TYPE field.
- Holt_ddh_OGS_Legend_Colours.fvp – OGS legend colours applied to the down-hole geology on the drill-hole dataset. To be applied to the OGS_Conversion field.
- Holt_Structure_Legend_Colours.fvp –legend colours applied to the down-hole geology on the drill-hole dataset to highlight the structural data only (i.e., faults, shears etc.). To be applied to the OGS_Conversion field.

COORDINATE SYSTEM TRANSFORMATIONS

All data was initially received in the Holt-McDermott Mine grid as defined by Newmont Mining Corporation. This mine grid was defined and stored in the FracSIS database so that a coordinate transform could be applied within the FracSIS software. The coordinate system file was also stored in the project folder in the "Coordinate System Definitions (csd)" subfolder as a file called "Holt McDermott Mine Grid.csd". This definition may be used/imported in other projects (i.e., gap analysis for Holloway and Holt-McDermott). The local grid system is defined as follows:

Target projected coordinate system: NAD83, UTM Zone 17N

- Transform from local point:
  - Easting: 9997.9250 m
  - Northing: 10848.0820 m
  - Height: 4998.9600 m
- To projected point:
  - Easting: 592557.2130 m
  - Northing: 5374686.2570 m
  - Height: 290 m
- Counterclockwise rotation of 16.57°

Scope for Further Improvement

As with all modelling, there is always room for improvement, and interpretations are constantly evolving as a result of data integration and 3D modelling in general. For the Holt-McDermott deposit, the 3D interpretation was made based on an initial interpretation that was done in 2D from projected drill holes onto plans and sections. The major fault contacts were mostly complete, however, most of the lithological contacts were partial. The initial 2D interpretation could be further constrained by the 3D drilling and newly unified legend.

A partial regional model has been constructed. However, it would be possible to construct a more complete regional contact model of the various lithological units from existing drill-hole information, more importantly because deposit models exist for both Holt-McDermott and the nearby Holloway deposit to the north (Figure 9).

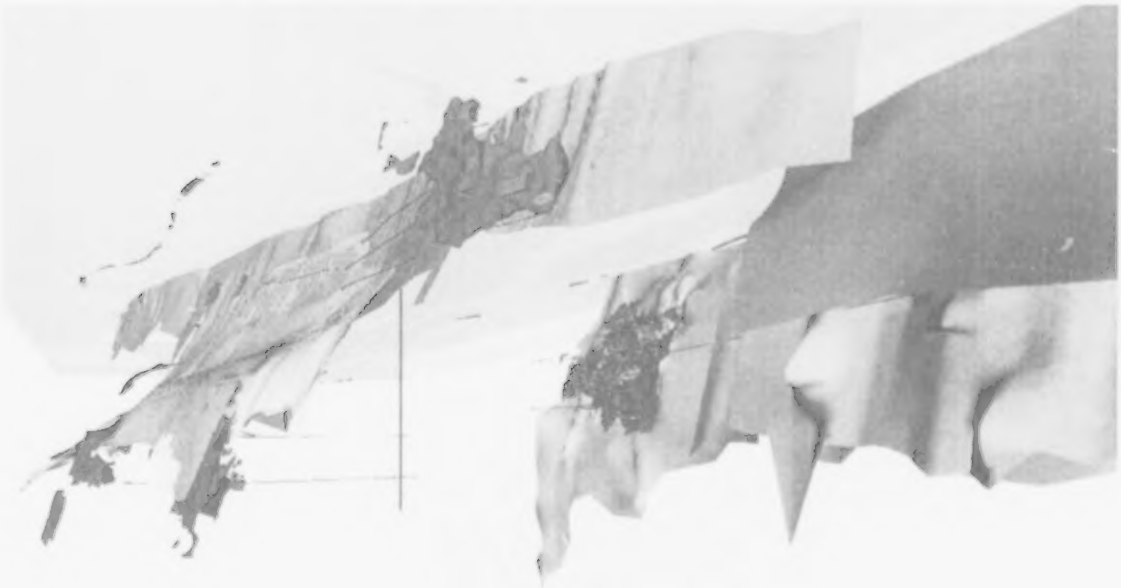

Figure 9. Oblique view looking approximately northwest: Holt-McDermott on the south side (left side of image) and Holloway to the north (right side of image). (See chart in back pocket for colour version of this figure.)

Kirkland–Larder Fault-Related Gold Deposits (Kirkland Lake Camp)

The Kirkland Lake area is one of the most prolific gold camps in northern Ontario and ranks second in Canada in terms of ounces of gold produced. From 1910 to 1999 approximately 37 million ounces of gold have been produced from 28 mines, with an historical average grade of 11.7 grams/tonne. Prospecting for gold in the Kirkland Lake area dates back more than 100 years. Gold was first discovered in the camp in 1906 with the first production from the Gateford Mine (Swastika) in 1910. Production was continuous for 90 years, when in 2000 the Macassa Mine was closed. In 2002, Foxpoint Resources (now Kirkland Lake Gold Inc.) re-opened the Macassa Mine and plans to produce gold at a rate of 50 000 to 70 000 ounces per year.

The gold deposits in the Kirkland Lake area are generally all located on crustal-scale structures within a 4 km corridor centred on the Cadillac–Larder Lake deformation zone. The structures acted as conduits that tapped deep-seated hydrothermal systems along which gold-bearing solutions travelled and formed deposits.

The gold-bearing structures in the Kirkland Lake area continue laterally for many kilometres, and display a significant vertical component. Mining on the Main Break (Kirkland Lake fault) reached depths of 2.4 km (8000 feet) at the Lakeshore Mine, now owned by Kirkland Lake Gold Inc, with ore intersections to 3 km. On the Upper Canada Break, ore was mined to a depth of 1.8 km (6000 feet) with ore grade drill intersections to 2 km, and at the Kerr Addison Mine, ore on the Larder Lake Break was mined to a depth of 1.4 km.

Gold mineralization in the Kirkland Lake camp generally occurs in 4 rock types that are cut by the major structures. These include syenitic (alkalic) intrusive rocks, mafic volcanic flows, altered ultramafic rocks and trachytic (Timiskaming age) pyroclastic and sedimentary rocks. Seven mines along the Kirkland Lake Main Break (Toburn, Sylvanite, Wright-Hargreaves, Lakeshore, Teck-Huges, Kirkland Lake Minerals, and Macassa) produced 24 million ounces of gold from quartz vein and breccia zones hosted in felsic and mafic syenitic (alkalic) rocks. The Kerr Addison Mine, located in Virginiatown along the Larder Lake Break, produced 11 million ounces of gold from quartz vein and breccia zones hosted in both altered ultramafic volcanic rocks (green carbonate) and mafic volcanic flows. The Upper Canada Mine produced 1.5 million ounces of gold from quartz vein zones hosted in trachytic pyroclastic and sedimentary rocks along the Upper Canada Break.

KIRKLAND LAKE GOLD INC.: MACASSA AND KIRKLAND LAKE MINERALS MINES

General Information

- Mine site locations: Teck Township (see Ayer and Trowell 2000)
- Deposit type: Archean lode gold
- Property owner: Kirkland Lake Gold Inc.
- Data donor(s): Kirkland Lake Gold Inc., Ontario Geological Survey (OGS)

- Model built by: P. Vasak, with assistance from C.A. Hawson, P.Geo., J. Whitmore, G. Wang, D. Muldowney and G. Yang
- Checked by: M. Sutton, P.Geo., and S. Carmichael, P.Geo., Kirkland Lake Gold Inc.

Background

Kirkland Lake Gold Inc. (KLG) acquired 5 of the 7 past-producing mines within the Kirkland Lake mining camp. These properties include (from west to east along the Kirkland Lake main break): Macassa, Kirkland Minerals, Teck-Hughes, Lakeshore, and Wright-Hargreaves mines. The properties are in eastern Teck Township and western Lebel Township in the district of Timiskaming, Ontario (Figure 10). Collectively, the past-producing mines produced 24 million ounces of gold from 1919 to 1999. Historically, the KLG properties produced 90% of the gold in the Kirkland Lake camp.

The Macassa Mine is the westernmost of the 5 properties and was in continuous production from 1933 until operations were suspended in June 1999. A total of 3 540 601 ounces of gold at an average grade of 0.45 ounces/ton was mined during this period (KLG website, www.klgold.com, accessed March 2004). The mine is again in production since May 2002 when it was reopened by Foxpoint Resources Ltd.

The Kirkland Minerals Mine is bounded to the west by the Macassa Mine and to the east by the Teck-Hughes Mine. A total of 1 172 955 ounces of gold at an average grade of 0.37 ounces/ton was mined between 1919 and 1960 (http://www.klgold.com/kirklandmineral.htm).

Figure 10. Detailed map identifying the number of ounces of gold produced in the past from the 5 mines currently owned by Kirkland Lake Gold Inc. (http://www.klgold.com/geology.mainpage.PDF, 2005).

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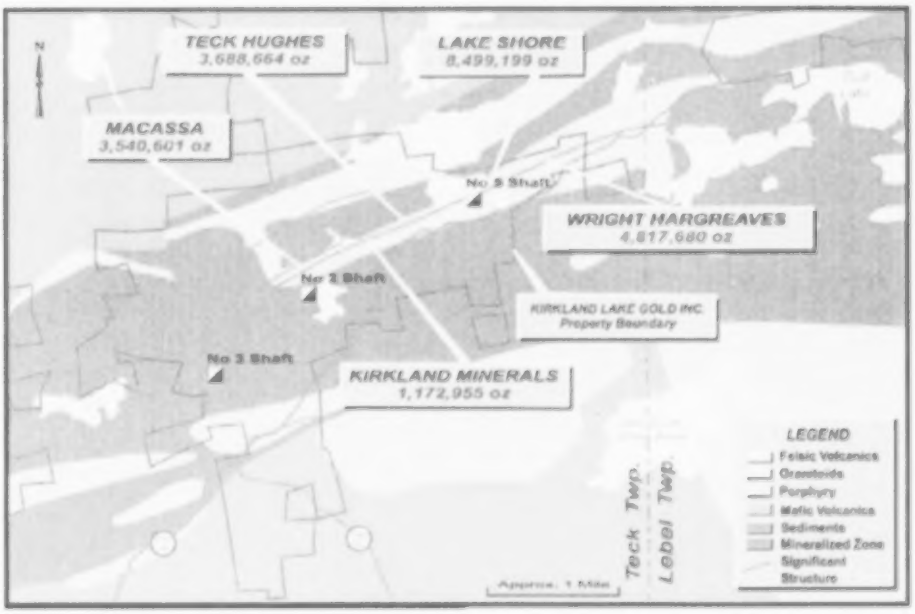


Figure 10. Detailed map identifying the number of ounces of gold produced in the past from the 5 mines currently owned by Kirkland Lake Gold Inc. (http://www.klgold.com/geology/ounces, PDF 2005).

Deposit Setting

The Macassa and Kirkland Lake Minerals deposits are typical Archean lode gold deposits hosted in a set of mineralized quartz veins within a syenite sill near the Cadillac–Larder Lake deformation zone, a regional-scale strike-slip shear zone. Gold occurs in quartz veins associated with the Kirkland Lake Fault. The Kirkland Lake Main Break is a fault zone branching northeast from the Cadillac–Larder Lake deformation zone in the vicinity of Kenogami Lake, and passes through all the gold mines in Kirkland Lake (http://www.discoverabitibi.com/kirkland%20Lake)3.pdf, accessed March, 2005). The ore is found in 3 general structural settings: "break ore", "vein ore", and "breccia ore". The "break ore" is hosted in branching, sub-parallel, steeply dipping faults that include the Kirkland Lake Fault (locally known as the Main Break), '04 Break, '05 Break and '06 Break. The "vein ore" is found as a series of stacked, steep- to shallow-dipping, gold-bearing, fracture-filling quartz veins that occur between the steeper "breaks" or faults. The "breccia ore" occurs as volumes of fault-bounded, brecciated white quartz cemented by grey cherty quartz (Info-mine, 2004).

Data Donors and Sources

1. KLG provided on-site access to historical plans and sections developed during the operating period. Scanning of the documents was carried out by BLAZE Information Technology Inc. (BLAZE I.T.). BLAZE I.T. was also contracted to carry out the vectorization of the scanned images and provide the data in digital format as AutoCAD drawing files with geological contacts, structure and other related information saved to different drawing layers for later extraction and use.
2. KLG also provided a Datamine 3D model that contains mine infrastructure (drifts and shafts), mined stopes, ore reserves, resource wireframes and ore-mineralized zones (M. Sutton, KLG, personal communication, 2005). Drill-hole files containing gold assay data (ounces per ton), lithological units, structural definitions and alteration classifications were also included in the Datamine database.
3. KLG provided data that was in Macassa Mine geology grid coordinates.
4. Surface map information was provided by the Ontario Geological Survey (Ayer et al. 2004).
5. Supplemental surface geology was provided by MERC (Ispolatov 2005).
6. All surface map information was provided in digital form in NAD83, UTM Zone 17N grid coordinates.
7. The legend for the surface geology and, where appropriate, the underground geology, has been correlated with the regional-scale OGS legend used in Ayer et al. (2004).
8. Legend colours are derived from those used in Ayer et al. (2004).
9. Geographic data, Landsat imagery and geophysical maps were extracted from Ayer et al. (2004).
10. Additional plans and sections for the Kirkland Minerals Mine and the extreme east end of Macassa Mine were scanned from plans and sections from Thomson et al. (1948).

Modelling Procedure

A total of 102 Macassa Mine plans were scanned during the initial data collection trip to KLG and saved as *.TIF graphics files. The scales range from 1 inch to 20 feet (20 scale), to 1 inch to 100 feet (100 scale). The images were reviewed and evaluated for their data content, with particular attention to the presence of interpreted structural lines (faults, "breaks" and veins, Figure 11). A total of 38 images (thirty-four 20 scale and four 40 scale) were vectorized by BLAZE I.T. and data were saved in separate

layers in AutoCAD drawing file format. A further fifty-one 20 scale plans were vectorized by MIRARCO using ArcGIS and stored as shape files.

The vectorized lines from the scanned images were imported into the gOcad 3D earth-modelling package. Both engineering and geology grids were vectorized, and provided the reference points for georeferencing the information to the Macassa geology grid.

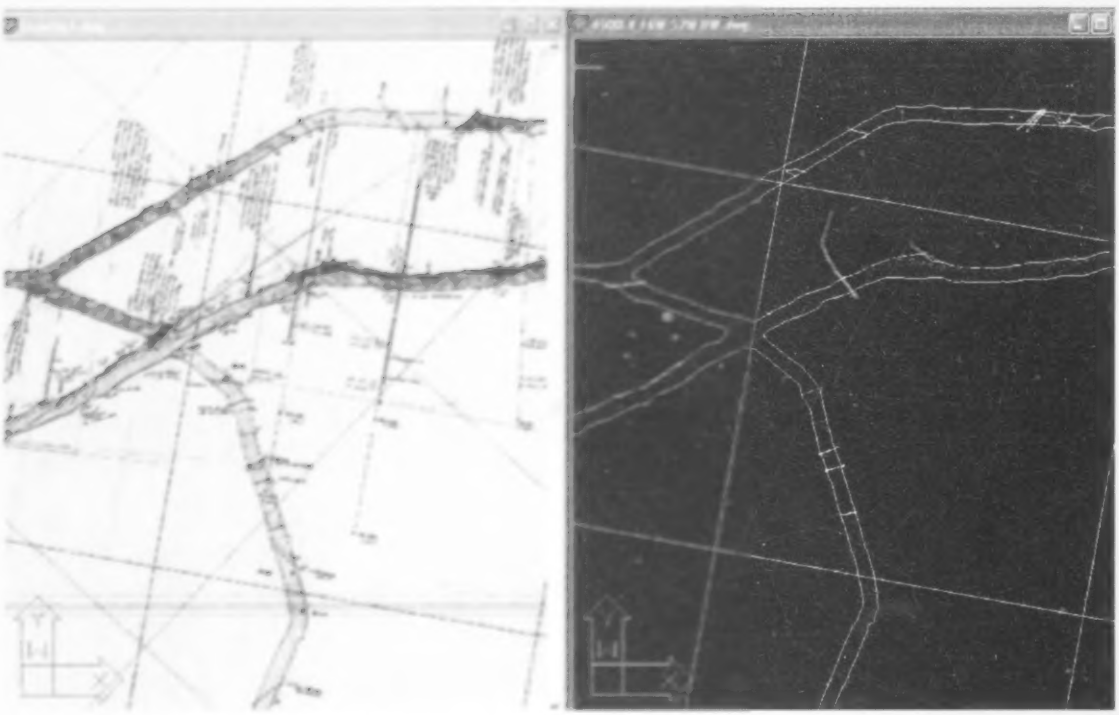


Figure 11. Left) Scanned plan showing drift mapping, structure and rock types, and **Right)** the same image vectorized in AutoCAD. (See chart in back pocket for colour version of this figure.)

Three sections with geologic interpretation (two 200 scale and one 50 scale) were scanned on a second data collection trip to the mine and vectorized using ArcGIS. The information was imported into gOcad as lines representing structural information, and coloured surfaces representing lithological information. The section data was georeferenced to the Macassa geology grid.

KLG provided a 3D Datamine model containing mine infrastructure (drifts and shafts), mined stopes, ore wireframes (reserves and resources), ore-mineralized zones, and drill holes containing gold assays (ounces per ton), lithological units, structural definitions and alteration classifications. The mine infrastructure, stopes and ore surfaces were exported in .dxf format, and polygon counts were reduced (where practical, without geometric distortion to the original objects) to about 50% of their former size using Poly Trans 3D translation software. This improved the ease of handling and display of the surfaces. Drill-hole data was exported as de-surveyed drill-hole files. At this stage, collar, survey, assay and lithology files were constructed, since this format is required by both gOcad and FracSIS for input. Mine-

specific lithological definitions or terms were correlated to the legend of Ayer et al. (2004) and the accompanying colour map files were created.

Data validation was done at each stage of the data transformation process.

1. Scanned images were checked before archiving. Problem images were discarded and rescanned.
2. Vectorized linework was compared to the original images with respect to accuracy of linework and its presence on the appropriate layer in AutoCAD. Where information was missing or improperly georeferenced, the vectorization was redone. In this modelling procedure, MIRARCO did capture all linework since some was penciled in, some line type conventions were not consistent from image to image, or over the historical life of the mine, and the quality of individual images varied.
3. Visual validation of imported digital data (gOcad and FracSIS models) was carried out by comparing the 3D objects to the original digital data (Datamine model). This included the 3D surfaces and drill-hole data.
4. Final validation of all objects in the 3D model were carried out by M. Sutton and S. Carmichael, KLG, at the Virtual Reality Laboratory facilities at Laurentian University. Modification of surfaces was done to conform to the local understanding of structures.

All 3D data was produced in the Macassa geology grid coordinate system and was linked to NAD83, UTM Zone 17N grid via the following No.3 Shaft transformation:

- 567819.5 Easting = -4096 MGG East
- 5331175.4 Northing = -808 MGG North
- 317.0 m ASL = 1039.98 feet ASL
- Rotation = 32.5° counterclockwise

There was neither the time nor the budget in this project to produce a comprehensive model involving alteration and lithological parameters. Therefore, at the direction of the Project Steering Committee and KLG, the emphasis was placed on structural modelling; lithological and alteration surfaces were not modeled in this project, however, lithology can be viewed on the drill holes and in the scanned sections.

Drill logs were correlated to the OGS legend used in Ayer et al. (2004) by C.A. Hawson, P.Geo., and checked by P.C. Thurston, P.Geo.

Geological structures (mainly steeply dipping fault systems) were recognized from the vectorized plans and sections. Additional structural information (faults, "breaks", veins, shears and breccia) was extracted from the drill-hole data and used to further constrain the modelled faults. Due to time constraints and the structural complexity of the mine, only the main structures consistently named on company plans and sections and in Thomson (1948) were modelled.

Stope and ore surfaces provided by KLG clearly identify the mineralized zones and provide good visual representations of the mineralized vein arrays away from the main "breaks", therefore, no additional work was done to build vein arrays.

Gold assay values were extracted from the drill-hole database and are presented as a data pointset in units of ounces per ton.

Scope for Further Improvement

There is a wealth of information for Macassa Mine, in particular. The mine structural setting is highly complex and could not be modelled in detail due to time constraints. There is also a good drill-hole dataset for lithology and alteration, however, due to priority considerations, these were also not modelled.

The model could be improved by:

1. Modelling geological units from markers on the drill holes and from the drift mapping captured in the mine plans.
2. Modelling alteration zones from markers on the drill holes and drift mapping.
3. The model created is a generalized mine-scale model. More detailed structural modelling could be carried out in specific locations in the mine where warranted. For example, along the '05 Break near the No.3 Shaft where there is a convergence of a regional shear zone, several vertical mineralized veins, the '05 Break and the '05 Break South splay.

KIRKLAND LAKE GOLD INC.: WRIGHT-HARGREAVES, LAKESHORE AND TECK-HUGHES MINES

General Information

- Mine site locations: Teck Township (see Ispolatov 2005)
- Deposit type: Archean lode gold
- Property owner: Kirkland Lake Gold Inc.; previously, Foxpoint Resources, Kinross, Wright-Hargreaves, Lake Shore, Teck-Hughes
- Data donor(s): Kirkland Lake Gold Inc., Ontario Geological Survey (OGS)
- Model built by: C.A. Hawson, P.Geo., with assistance from L. Robertson, J. Whitmore, R. Anderson, F.D. Prévost, L. Cotesta and P. Vasak
- Checked by: M. Sutton, P.Geo., and S. Carmichael, P.Geo.

Background

Kirkland Lake Gold Inc. purchased the Macassa Mine, the 1500 ton per day mill and 4 former producing gold properties—Kirkland Lake Gold, Teck-Hughes, Lakeshore and Wright-Hargreaves—in December 2001. Between 1913 and 1999, these 5 properties (Figure 12) produced more than 22 million ounces of gold. The strike length of the properties is more than 7 km between the Macassa Mine in the west and Wright-Hargreaves to the east. This is the first time the properties are being developed and explored by one owner. This camp is located in the Abitibi greenstone belt at Kirkland Lake in Teck Township, Ontario. The model presented here represents the former Teck-Hughes, Lakeshore and Wright-Hargreaves properties.

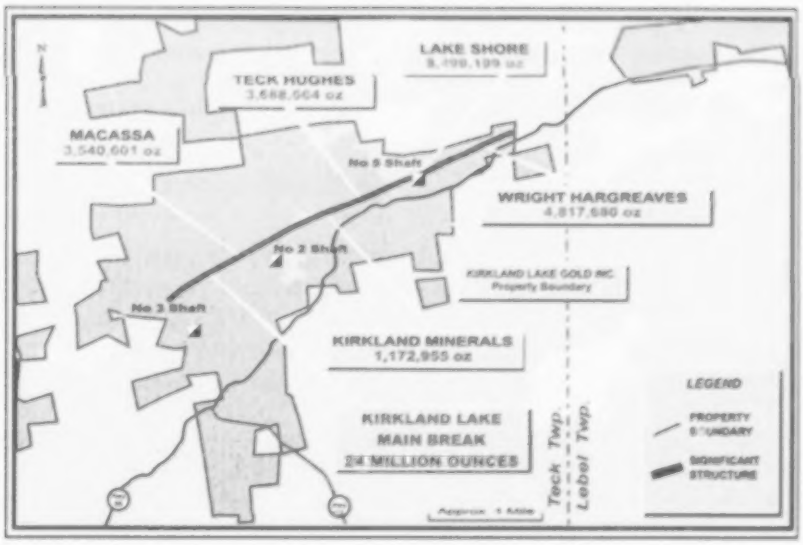


Figure 12. Kirkland Lake main geological break and Kirkland Lake Gold Inc. property limits (klgold.com).

Deposit Setting

Teck Township comprises mafic metavolcanic rocks of the Tisdale and Kinojevis assemblages and clastic metasedimentary and alkalic metavolcanic rocks of the Timiskaming assemblage (Ayer 2002). The Tisdale assemblage is cut by the syenitic Murduch Creek Pluton.

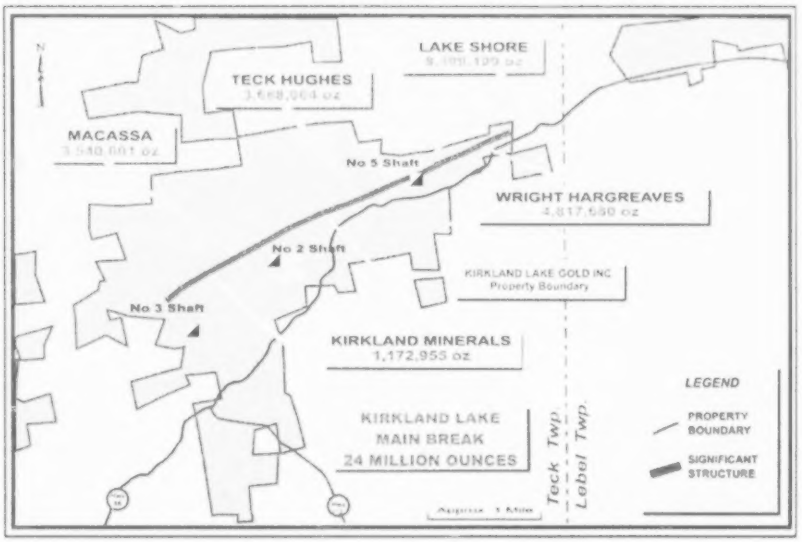
The following information is taken from http://www.klgold.com, with minor modifications. These deposits are typical Archean lode gold deposits with mineralization largely contained in quartz-vein systems within an alkaline syenite sill within Timiskaming stratigraphy.

WRIGHT-HARGREAVES

The first gold discovery in the Kirkland Lake camp was made by W.H. Wright in 1911. In 1913 the Wright-Hargreaves No.1 shaft was sunk. Gold production began in 1921 when a mill was constructed. Milling started at 175 tons per day. The mine was eventually developed down to the 8200-foot level, the deepest development in the Kirkland Lake camp. Diamond drilling below the 8200-foot level revealed several high-grade intersections persisting several hundred feet below the level. However, the cost to develop these intersections at such deep levels proved to be too high, and production was discontinued in 1965. Over the life of the mine, Wright-Hargreaves produced over 4.8 million ounces of gold.

Structure and Mineralization

The Main Break (Kirkland Lake fault) is the most prominent structure crossing the Wright-Hargreaves property. This structure has been traced to the 8100-foot level and, by diamond drilling, below this. A significant amount of ore was mined from this structure, however, most of the tonnage came from the North vein. The North vein branches off the Main Break to the north, just to the west of the property



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boundary with the Lakeshore Mine. Stoping on the North vein was extensive to about the 4500-foot level, and development was to the 6600-foot level. Below this level, mining was concentrated along ore-bearing fractures of the North vein zone known as the North Heading Vein, North vein, and North D Vein. These veins typically dip at about 75° south. Another significant mineralized structure is the South vein-fault, which branches off the south side of the Kirkland Lake fault in the western portion of the mine. There are other veins that splay off the main structures and form along tension fractures in the wedge of ground between major faults.

Post-ore faulting at Wright-Hargreaves is well documented in Thomson et al. (1948). The Lakeshore fault is the most important post-ore fault in the western portion of the mine. This fault strikes 012° to 025° and dips steeply to the east near surface, becomes vertical with depth, then by the 5000-foot level dips to the west. This cross-fault has several important faults branching off the east side of it, including the F and L faults.

A series of 4 major north-dipping "strike" faults have been numbered 1, 2, 6 and 5. Nos. 1 and 2 faults generally dip at 45°, or less, to the north and displace the Main Break and other vein zones some 150 and 300 feet, respectively, with reverse movement (hanging wall displaced over the footwall). The No.6 strike fault has the smallest displacement, averaging around 80 feet (again reverse movement), although it has a steeper dip of around 65°. The No.5 strike fault is the most important of these faults and crops out on surface as the Murdock Creek fault. It can be traced to the east across the Sylvanite and Toburn workings. The fault dips at about 45° north on the Wright-Hargreaves property, but the dip appears to steepen with depth. Displacement on this fault has a maximum of 700 feet (reverse movement) on the Wright-Hargreaves property.

Most of the ore mined at Wright-Hargreaves was found within syenite porphyry, with veins north of the Main Break below the 6600-foot level mainly in tuff, greywacke, conglomerate and granite porphyry located in the footwall of the main syenite porphyry plug. The Main Break is located within syenite porphyry throughout the mine. The north veins below the 6600 foot level are much less continuous than veins in the upper levels hosted by syenite porphyry.

LAKESHORE

The Lakeshore Mine is located in the centre of the Kirkland Lake camp and is bounded to the west by the Teck-Hughes Mine and to the east by the Wright-Hargreaves Mine. The Lakeshore Mine produced 8 499 199 ounces at a grade of 0.51 oz/ton and was in continuous production from 1918 until 1965. This output represents 36% of the total production from the entire camp. Additional amounts of gold were recovered from pillars in later years.

Harry Oakes discovered gold in 1911. In 1913 Oakes purchased the adjoining claim to the west. From 1914-1918 the No.1 Shaft was developed to 400 feet on the South (No.1) Vein Zone and 7464 feet of underground development on levels at 100, 200, 300, and 400 feet was carried out. A 65-ton mill was installed and milling began in 1918. All work was carried out by Lake Shore Gold Mines Limited.

Production over the period 1919-1965 eventually required 4 surface shafts and 3 internal shafts. The original No.1 Shaft and its extension were both inactive during the latter years of operation. The No.4 Shaft, collared at 4325-foot level, took the workings to a depth of 8150 feet. Milling capacity was gradually increased to a maximum of 2400 tons per day, and production was continuous until the mine closed in July 1965. Ore from the Wright-Hargreaves Mine was treated at the Lakeshore mill from 1957 until the closure of that mine in March 1965.

High-grade ore material, on the bottom levels, was still being mined when the mine closed. Diamond drilling below these levels indicated that the ore continues and that the Main Break shows no signs of weakening at depth. Relatively low tonnage of ore at deeper levels and difficulties in mining at these extreme depths proved deepening of the mine workings to be uneconomical with the fixed gold prices of the day.

Structure and Mineralization

The Main Break and related sub-parallel structures extend continuously across the Lakeshore property but are offset by significant post-ore faulting along the Lakeshore fault at the east end of the property. Near surface, offset on this fault is 600-750 feet horizontally and about 325 feet vertically, with the east side moving down, and north, relative to the west side. The fault strikes about 012° and dips sub-vertically to the southeast. At deeper levels the fault appears as a strike fault and merges with the No.5 fault between the 6325 and 6825-foot levels. At the bottom levels of the mine, the strike of the fault follows the North vein.

The North, or No.2, vein is the most productive and extensive structure at Lakeshore. This structure is continuous from surface down to the 8075-foot level and has been traced by diamond drilling for 800 feet below this level. Between the 1200 and 4000-foot levels the Main Break branches into several faults. The North vein is the continuation of the Main Break at the west end of the property. At the east end of the property the Main Break is represented by the South, or No.1, vein, which continues as the South vein on the Wright-Hargreaves property.

Mining on the North (No.2) vein was extensive throughout the mine. Of these zones, the area containing mixed syenite porphyry and augite syenite west of the shaft area from surface to the 5450-foot level was most productive. Occasionally, sub-parallel veins were mined separately from this vein, but in places the veins are closely spaced and have been stoped together across widths up to 70 feet. Stoping was nearly continuous on the North vein from surface to the 5400-foot level, where veining weakened considerably and stopped at the 6325-foot level. Another ore shoot continues below this from the 7575 foot level to the 8075-foot level, the bottom level of the mine. This ore shoot was traced by diamond drilling down to 8500 feet and showed no signs of weakening. The North vein on the 8075-foot level was mined over an 807-foot strike length at an average stoping width of 7 ½ feet and an average grade of 0.677 oz/ton.

The South (No.1) vein was second in importance to the North vein. This structure contains numerous branches or splays and related veining but is less continuous than the North vein. The ore was not as extensive, with lower average stoping widths varying from 3 to 35 feet. Above the 1000-foot level, the South vein is regular and is sub-parallel to the North vein, which is some 400 to 500 feet to the north. Below the 1000-foot level, the South vein is much less regular and less continuous until the ore bottoms out on the 6075-foot level.

Several subsidiary veins have also been mined in the ground adjacent to these main structures. Most of these veins occurred between the North and South veins, where they formed along tensional fractures related to fault movements.

Another significant structure, sub-parallel to the North vein, occurs some 1200 to 1600 feet to the north. It is referred to as the Narrows "break", or No.3 vein zone, and has been drilled and explored on various levels down to the 5450-foot level. While some high-grade intersections have been reported, no significant amounts of ore have been mined from this zone. This structure likely continues to the west and east and is called the '05 Break at the Macassa Mine.

Mining at Lakeshore was almost entirely within intrusive rocks except in the upper levels of the mine to the 800-foot level, where ore was found in conglomerate on the north side of the North (No.2) vein. Most of the ore is hosted in syenite porphyry, with augite syenite hosting some ore at the west end of the property. Syenite porphyry is the only rock type reported in the lower levels of the mine.

TECK-HUGHES

The Teck-Hughes Mine is bounded on the west by Kirkland Lake Minerals (formerly Kirkland Lake Gold) and by the Lakeshore Mine on the east. The mine began production in 1917 and had produced 3 688 664 ounces of gold at a recovered grade of 0.38 oz/ton when operations ceased in 1968. The mine ranks third among the 7 mines of Kirkland Lake in terms of total ounces produced, but had an average recovered grade considerably below the camp-wide average of 0.46 oz/ton.

In 1911, 3 claims (Tl 6624-Tl 6626) were staked by S. Orr and 3 neighbouring claims (Ll 238-Ll 240) were staked by J. Reamsbottom. In 1912, gold was discovered on claim Ll 238 by J.A. Hughes and S. McIntyre. Prospecting and surface trenching were carried out by Teck-Hughes Gold Mines Limited and a 35-foot shaft was sunk.

In 1913, the No.1 Shaft was sunk to 212 feet and 203 feet of drifting was carried out on the 200-foot level. The No.2 Shaft was sunk to a depth of 75 feet with 500 feet of lateral development on the 75-foot level by Teck-Hughes Gold Mines Limited. From 1914 to 1915 the No.3 Shaft was sunk to 124 feet and an 85-foot winze was developed from the second level. A total of 1360 feet of lateral development in No.1 and No.3 shafts were carried out by Nipissing Mining Company (under option from Teck-Hughes Gold Mines Limited).

From 1915-1917 the underground workings were dewatered and the No.3 shaft was deepened to 400 feet with a winze to 600 feet, and 1804 feet of lateral development was carried out. In 1917, a 50-ton mill was installed and milling began. This work was completed by Teck-Hughes Gold Mines Limited.

Structure and Mineralization

The most important structure at the Teck-Hughes Mine is the Kirkland Lake Main Break. This structure and the veins related to it yielded most of the gold in the mine. The mineralized structure was mined as the No.3 vein from surface to the 6105-foot level, the deepest level at the mine. Longitudinal sections reveal that stoping on the No.3 vein was almost continuous from surface to near the 3000-foot level. Diamond drilling defined the Main Break down to 6650 feet, however there was insufficient ore to warrant development below the 6105-foot level. Grade and production both decreased below 3000 feet. This decrease in ore with depth has been suggested to be directly related to a decrease in the proportion of augite syenite to syenite porphyry with depth (Charlewood 1964).

The No.4 "break" lies about 600 feet south of the Main Break and is generally believed to be the westerly extension of the South (No.1) vein of Lakeshore Mine. Although this structure contains some low gold values, no ore has been mined along it in the Teck-Hughes Mine. This fault may merge with the No.6 break at depth and has never been identified in the western portions of the mine.

From 1938 onwards, veins in the hanging wall of the Main Break became an important source of ore. These hanging-wall veins are typical of other such veins in the Kirkland Lake camp, which drape off the Main Break and dip flat to the south, generally between 30 and 50°.

The relatively late discovery and subsequent mining of hanging-wall veins can be attributed to a number of factors. Firstly, mining was concentrated on the Main Break where stoping was extensive, and easily traced. Secondly, many of the initial diamond-drill holes testing for ore associated with the Main Break were not extended any significant distance into the hanging wall. In later years, improvements in diamond drilling and reduced drilling costs, increasing realization of the significance of the hanging-wall veins, and the depletion of Main Break ore led to more and more exploration holes probing the hanging wall of the Main Break, revealing numerous significant ore-bearing veins.

Data Donors and Sources

- KLG provided on-site access to 1:100 scale historical plans developed during the operating period. Scanning of the documents was carried out on-site by BLAZE Information Technology Inc. (BLAZE I.T.).
- KLG also provided a Datamine 3D model that contained mine infrastructure (drifts and shafts), mined stopes, ore reserve, resource wireframes and ore-mineralized zones (M. Sutton, KLG, personal communication, 2005).
- Drill-hole files containing gold assay data (ounces per ton and dollar value), lithological units, structural definitions and alteration classifications were also included in the Datamine database. Drill-hole data for about 6600 holes is included with the model, but is a far from complete dataset, as the conversion from analog to digital data is an ongoing process.
- Digital data was provided in Macassa Mine geology grid coordinates.
- Generalized sections and plans from Thomson et al. (1948) were scanned and utilized in construction of the 3D mineral deposit models.
- The regional surface map in this project is from Ayer et al. (2004). A local pre-publication township map at a scale of 1:10 000 (Ispolatov 2005) was used for more detailed surface geology.

Modelling Procedure

The 1:100 scale plans from each property were scanned, and stored as *.TIF images. These images were imported into ArcGIS 9.x, where they were georeferenced to the mine grid used on the plans. The geology and engineering grids for each of the 3 mines were different from each other and from the Macassa grid. The relationship to the Macassa grid is shown in Table 8.

Table 8. Grid systems for Wright-Hargreaves, Lakeshore and Teck-Hughes mines relative to the Macassa grid system of Kirkland Lake Gold.

Grid No.	Description	Clockwise Grid System Rotation to Macassa Engineering Grid	Common Point Coordinates					
			Macassa Engineering Grid			Grid System		
			X easting	Y Northing	Z elevation	X	Y	Z
1	Macassa Engineering Grid	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Macassa Geology Grid	-32.50	12415.60	11753.29	0.00	0.00	0.00	0.00
3	Lakeshore Surface Coordinates	-1.39	18325.52	17264.91	0.00	11000.00	11000.00	11040.00
4	Lakeshore Geology Grid	-20.32	18325.52	17264.91	0.00	-1695.00	0.00	11040.00
5	Teck-Hughes Engineering Grid	-0.67	18325.52	17264.91	0.00	3000.00	1000.00	11040.00

The following line work was captured: faults, veins, and lithology. Shape files were created for each type of feature captured and imported into gOcad using the native importer, and then elevation (Z) was applied.

The 600-foot level from Thomson et al. (1948) was imported into gOcad and georeferenced against the ArcGIS map of Ispalotov (2005) for each property. This was necessary so as to correctly position the vertical sections from Thomson et al. (1948). Thus the 600-foot level plan was georeferenced for Teck-Hughes, Lakeshore, Wright-Hargreaves and also the Sylvanite Mine (owned by Queenston Mining Inc.). It was necessary to georeference for each property because the section produced by Thomson did not normalize the mine grids of each property to any one mine, thus the structures would be incorrectly displayed when built for a more regional scale. This georeferencing was an approximation at best, due to distortion in the previously folded plans from Thomson et al. (1948).

The final grid used for construction of the model is the Macassa Mine geology grid. The conversion is as follows:

Teck-Hughes

- BEGIN {a=12.5/57.29578;X1=6438.6;Y1=-104.3;}
- {x0=X+6655-X1;y0=Y-Y1;
- X=X1+x0*cos(a)+y0*sin(a);
- Y=Y1+y0*cos(a)-x0*sin(a);}

Lakeshore

- Y=YC+y0*cos(a)-x0*sin(a);

Wright-Hargreaves

- BEGIN{XT=10781;XC=11071.4;YC=-701.7;a=32.5/57.29578;}
- {x0=X+XT-XC;y0=Y-YC;
- X=XC+x0*cos(a)+y0*sin(a);
- Y=YC+y0*cos(a)-x0*sin(a); }

Grid conversion for the final FracSIS model was carried out in FracSIS. The mine coordinate system is rationalized by taking the location in mine coordinates and the final coordinate system (NAD 83, UTM Zone 17N).

Data Import and Modelling Conventions

1. Data validation:
    a. Digitizing of mine plans and sections was carried out in-house, the plans were georeferenced to the individual mine's geology/engineering grid and were brought into the Macassa grid within gOcad. Where problems were encountered, plans and sections were redigitized as necessary.
2. Modelling software: gOcad 2.0.8.
3. Modelling process:
    a. Structures were the first priority in modelling given the structural control of this deposit type.
    b. Lithology was not regarded as a priority as the geometry of the host rock types is not very variable and, therefore, rock types were not modelled in this project.
4. Items of importance to the company are:
    a. Post-ore structures
    b. Major strike structures
    c. Vein arrays
5. Drill logs were correlated to the OGS legend of Ayer et al. (2004) by C.A. Hawson, P.Geo., and checked by P.C. Thurston, P.Geo.
6. It was not possible to identify stratigraphic units from the mine level plans for the Wright-Hargreaves level plans, nor in any great detail for either Lakeshore or Teck-Hughes. Faults, veins and 'breaks' were, however, well documented on the level plans and were captured as their own shape file when uniquely labelled.
7. Geological structures were recognized from the plans and sections. Drill-hole data was not available for use in this project at a sufficiently early stage because of the difficulty in simplifying the data within a limited amount of time. In addition, drill data was limited in extent for these 3 properties.
8. Lithological modelling was not carried out, and alteration was not taken into account as limited information on alteration was available.
9. Stopes and ore reserves as provided by the data donor, Kirkland Lake Gold Inc., were included in the model but are not complete. The surfaces were imported from Datamine and, after importing, no further manipulation was carried out.
10. Assay data (Au oz/ton) is only available as part of the drill logs and therefore is only a partial dataset.
    a. NB: the assay data for the Wright-Hargreaves Mine is a dollar value with no date attributed to the drill-holes, therefore, this data should be treated carefully.
    b. Mineralized zones were not categorized in this model.

Scope for Further Improvement

There is a plethora of data available for these 3 properties: Wright-Hargreaves and Lakeshore mines are the 2 deepest mines in this area of the Kirkland Lake mining camp. Given the time and budget constraints, it was not possible to fully digitize and build a full structural model. Nor was it possible to embark upon a lithological model, which would have to be constructed from the drill logs. In addition, not all lithological data exists in a digital form, further hampering attempts to build a lithological model.

Given sufficient time, a significantly more detailed and complete 3D mineral deposit model of the Kirkland Lake Gold properties could be produced.

The following can be incorporated to improve the model:

1. Model geological units from markers on the drill holes and drift mapping captured in the mine plan scanning and digitizing process.
2. Model alteration zones by extracting marker information from the drill-hole database.
3. Model Wright-Hargreaves and Lakeshore mines to depth, to better illustrate the rotation of mineralization in the Lakeshore Mine.
4. Incorporate mine sections (if any) to better identify the "flat"-lying veins and structures.
5. Incorporate information from the Sylvanite Mine and other properties to the south and west if information becomes available.
6. Incorporate elements of all properties owned by Kirkland Lake Gold into one model. This would be limited by available computing power.

QUEENSTON MINING INC.: ANOKI AND MCBEAN DEPOSITS

General Information

- Mine site location: Gauthier Township (see Ispolatov and Lafrance 2005)
- Deposit type: Archean lode gold
- Property owner: Queenston Mining Inc.
- Data donor(s): Queenston Mining Inc., Inco Ltd. and Ontario Geological Survey (OGS)
- Model built by: C.A. Hawson, P.Geo., with assistance from F.D. Prévost, P. Vasak, L. Cotesta, J. Whitmore, G. Wang and G. Yang.
- Checked by: C. Page, P.Geo., and D. Alexander, P.Geo., Queenston Mining Inc.

Background

KIRKLAND LAKE GOLD PROJECT, ONTARIO

The following is extracted from http://www.queenston.ca/projects/ kirkland.html with some minor changes.

Between 1996 and 2002 the Kirkland Lake project was held through a 50-50 joint venture with Franco-Nevada Mining Corporation Limited. The joint venture was formed to explore for new and deeper gold deposits in the Kirkland Lake gold camp, one of Canada's highest grade gold camps. Subsequent to the merger of Franco-Nevada with Newmont Mining and Normandy Mining to form Newmont Mining Corporation, on July 19, 2002, Queenston Mining Inc. purchased Newmont Mining's interest in the joint venture. This has given Queenston Mining Inc. sole possession of one of Canada's premiere gold exploration projects.

Queenston Mining Inc. holds a combination of 742 patented, leased and unpatented mineral claims covering 12 000 ha in the Kirkland Lake area. This holding is the single largest, contiguous land package ever assembled in the Kirkland Lake camp. On the property, 4 mines (Sylvanite, Upper Canada, McBean, and Upper Beaver) have produced 3.4 million ounces of gold, and there exist 3 gold deposits (Anoki,

Amalgamated Kirkland (AK), and 180 East). These deposits host combined measured and indicated resources of 4 134 453 t averaging 5.6 g/t (approximately 744 000 ounces) and inferred resources of 4 474 568 t averaging 5.3 g/t (approximately 763 000 ounces) (http://www.queenston.ca/projects/kirkland.html). The mineral resources reported for the Kirkland Lake gold project are classified in accordance with definitions and guidelines adopted by the Canadian Institute of Mining, Metallurgy and Petroleum (CIM), that is, they are pre-NI 43-101. In addition to the deposits, there are a further 50 gold showings and/or zones on the properties and an office located at the Upper Canada Mine.

Deposit Setting

The Anoki deposit is situated in the hanging wall of the Larder Lake Break; the McBean deposit is situated within the Larder Lake Break. Areas of mineralization have been identified in the footwall, the deformation zone and in the hanging wall.

In 1996, drilling below the McBean deposit (1 559 450 t grading 5.1 g/t) discovered 3 zones of green carbonate mineralization in the central and footwall portions of the Cadillac–Larder Lake deformation zone. These zones vary from 3 to 30 m wide, and contain free gold in pyritic sections of the green carbonate, in felsic dykes and in quartz veins and stockworks. Eleven holes outlined an inferred resource of 1 111 300 t at a cut grade of 7.5 g/t. For this calculation, assays over 34.3 g/t were cut to 34.3 g/t. The uncut grade of the resource is 18.9 g/t. The McBean green carbonate zone plunges to the east, below the Princeton property, where it remains open (http://www.queenston.ca/projects/kirkland.html).

Data Donors and Sources

1. Data Donor: Queenston Mining Inc.
    a. Mine plans were scanned on-site, September 2004.
        i. Digitizing of mine plans carried out November 2004, using ArcGIS 8.3
    b. Scanned mine plans, digitized mine plans and sections, and AutoCAD drawings were imported into gOcad.
    c. GIS data are from regional topographic coverage in Ayer et al. (2004) and Ispolatov and Lafance (2005).
    d. 3D models and format, resource model for Anoki mineralization and Anoki Deep (pre NI 43-101) provided by Queenston Mining Inc.
2. Drilling
    a. Most drill-hole data was provided in an Excel spreadsheet by Queenston Mining Inc. Coordinates were provided in the Anoki grid and NAD27, UTM Zone 17N.
    b. Lithological data and assay data for 66 holes were supplied at a later date, converted from *.IN files and brought into Excel. From there they were brought into gOcad.
    c. Collar and survey files were used as provided by Queenston Mining using the Anoki grid.
    d. The lithology file for drill holes was simplified and correlated with the OGS legend used in Ayer et al. (2004). This, in part, was to correlate the rock types involved in all the properties in this project. This was done with the idea of enhancing prospectivity as well as creating a harmonious project.
3. Surface Maps
    a. P.3546–Revised, Gauthier Township Transect (Ispolatov and Lafance 2005), scale 1:10 000, UTM Zone 17, NAD 83.
    b. MRD 143, Geological compilation of the Abitibi greenstone belt (Ayer et al. 2004), scale 1:100 000, UTM Zone 17, NAD 83.

Modelling Procedure

1. Data import:
    a. The mine plans for McBean were at a scale of 1 inch to 100 feet, and were the original linen mine plans. These plans were scanned and stored as *.TIF images.
    b. Subsequently, these images were imported into ArcGIS, where they were georeferenced to the geology grid and the linework was digitized. Each different line type was saved as a separate shape file, e.g., faults, green carbonate, porphyry, etc.
    c. After digitizing, the shape files were imported into gOcad using the native importer, Z (elevation data) was applied in gOcad to match the level plans.
    d. Data was also imported from AutoCAD plans and sections. The layers required were exported from AutoCAD as *.dxf files and then imported into gOcad and georeferenced.
2. Grids:
    a. The geology grid for the original McBean plans is not the same grid as the geology grid for Anoki.
    b. The mine plans for McBean were translated to bring them into the current Anoki grid as follows:

```
BEGIN{XC=9728.14;YC=16467.9;}{ X0=X-XC;Y0=Y-YC;
X=XC+X0*cos(.285)-Y0*sin(.285);
Y=YC+Y0*cos(.285)+X0*sin(.285);}
```

3. Data validation:
    a. Since the plans and sections were worked on in-house, data validation was an ongoing concurrent process with ArcGIS open at the same time as gOcad, to check linework.
    b. Drill holes, making use of both zones and markers, were also used to help validate surfaces.
4. Modelling software:
    a. gOcad 2.0.8
5. Modelling process:
    a. Lithological units were recognized from the mine plans, drill logs and surface maps.
    b. Correlation to OGS compilation legend used in Ayer et al. (2004) was carried out by C.A. Hawson, P.Geo., and approved by D. Alexander, P.Geo. (Queenston Mining Inc.). Table 9 shows the original Queenston legend and the resulting correlation to the OGS legend used in Ayer et al. (2004).
    c. Structural information:
        (1) Fault recognition:
        - lines on plans and sections
        - DZ Deformation Zone
        - FAZ Fault Zone
        - MYL Mylonite
        - SHZ Schist/Shear
        - BBC Broken Blocky Core
        - LC Lost Core

        (2) Zones of alteration:
        - These were identified from the mine sections and plans and the drill-log information.
        - Zones of alteration consisted of: carbonatized units, veining, brecciation in any unit.
    d. Economic data:
        (1) Assay values were provided by Queenston Mining as part of the drill-hole information, and as pre-NI 43-101 resource information as Gemcom surfaces. The Gemcom surfaces were imported into gOcad to aid in model building, but

were not manipulated in any way. Raw assay data was "shrink wrapped" to indicate potential areas of interest.

e. Categories of mineralized zones:

(1) Mineralized areas were defined by C.A. Hawson, P.Geo., based on the presence of gold values, and ratified by C. Page, P.Geo., and D. Alexander, P.Geo. No numerical values, with regard to any economic potential, are to be credited to these mineralized areas.

(2) Newly recognized zones of mineralization are based on assay data obtained from the company as part of the information received in the drill logs. The files were converted to a point set in gOcad. The mineralized zones were delineated using a cut-off of 1 g/t Au and 3 g/t Au and the points were then "shrink wrapped" to indicate areas where exploration may be pursued with a greater chance of positive results.

(3) Pre-NI 43-101 resource shells were supplied by Queenston Mining Inc. for the Anoki deposit.

(4) As indicated by Queenston Mining Inc. (http://www.queenston.ca/projects/kirkland.html) drilling below the McBean deposit discovered 3 zones of green carbonate mineralization in the central and footwall portions of the Cadillac–Larder Lake deformation zone. These zones vary from 3 to 30 m wide and contain free gold in pyritic sections of the green carbonate, in felsic dykes and in quartz veins and stockworks. Eleven holes outlined an inferred resource of 1 111 300 t at a cut grade of 7.5 g/t. For this calculation, assays over 34.3 g/t were cut to 34.3 g/t. The uncut grade of the resource is 18.9 g/t. The McBean green carbonate zone plunges to the east, below the Princeton property, where it remains open.

Table 9. Queenston legend and the correlation with the legend used by the OGS in Ayer et al. (2004).

Queenston Legend			Final Queenston Legend for 3D Model and Surface Map	
CODE	DESCRIPTION	HEADING		
header	ALTERATION / VEINING			
CARB	Carbonatized Zone	Alteration/Veining	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
GCZ	Green Carbonate Zone	Alteration/Veining	1	Ultramafic (to Mafic) Metavolcanic Rocks/Intrusions
LIMN	Limonite	Alteration/Veining	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
QVZ	Quartz Vein Zone	Alteration/Veining		
TCS	Talc-Carbonate±Chlorite Schist	Alteration/Veining	1	Ultramafic (to Mafic) Metavolcanic Rocks/Intrusions
header	STRUCTURAL			
DZ	Deformation Zone	Structural		Fault
FAZ	Fault Zone	Structural		Fault
MYL	Mylonite	Structural		Fault
SHZ	Schist/Shear	Structural		Fault
header	OTHER			
BBC	Broken Blocky Core	Other		

Queenston Legend			Final Queenston Legend for 3D Model and Surface Map	
BX	Breccia	Other		
CTZ	Contact Zone	Other		
DYKE	Dyke	Other	12	Felsic to Intermediate Intrusive Suite
LC	Lost Core	Other		
header	INTRUSIVES			
1F	Felsite/Felsic Dyke	Intrusive	12	Felsic to Intermediate Intrusive Suite
1G	Granite	Intrusive	12	12b_Granite
1S	Syenite	Intrusive	13	13a Syenite, monzonite, granite
1Sa	Altered Syenite	Intrusive	13	13a Syenite, monzonite, granite
1SMa	Mafic Syenite	Intrusive	13	13a Syenite, monzonite, granite
1Sp	Porphyritic Syenite	Intrusive	13	13a Syenite, monzonite, granite
2D	Diorite	Intrusive	10	10a Diorite, gabbro, metagabbro
3D	Diabase	Intrusive	15	Diabase Dike
3G	Gabbro/Mafic Intrusive	Intrusive	10	10a Diorite, gabbro, metagabbro
3Ga	Altered Gabbro	Intrusive	10	10a Diorite, gabbro, metagabbro
3Gc	Carbonated Gabbro	Intrusive	10	10a Diorite, gabbro, metagabbro
3L	Lamprophyre	Intrusive	5	Alkalic and Subalkalic Metavolcanic Rocks/Intrusions (Unconformable Timiskaming Type) Alkalic Metavolcanic Rocks/Intrusions
4H	Hornblendite	Intrusive	9	Ultramafic Intrusive Rocks
4P	Peridotite	Intrusive	9	9a Peridotite, pyroxenite
4U	Ultramafics	Intrusive	9	Ultramafic Intrusive Rocks
4Uc	Carbonated Ultramafics	Intrusive	9	Ultramafic Intrusive Rocks
4Ui	Incipient Altered Ultramafics	Intrusive	9	Ultramafic Intrusive Rocks
4Y	Pyroxenite	Intrusive	9	9a Peridotite, pyroxenite
FP	Feldspar Porphyry	Intrusive	11	11b Quartz and/or feldspar porphyry
GRP	Granophyre	Intrusive	10	10d Granophyre
KIMB	Kimberlite	Intrusive	20	Kimberlite
M8	Amphibolite	Intrusive	9	Ultramafic Intrusive Rocks
PRPH	Porphyry	Intrusive	11	Porphyry Suite
QFP	Quartz Feldspar Porphyry	Intrusive	11	11b Quartz and/or feldspar porphyry
header	SEDIMENTS			
CHEX	Cherty Exhalite	Sediment	7	7d Silicate facies, chert
CHRT	Chert	Sediment	7	7d Silicate facies, chert
CHSD	Cherty Sediment	Sediment	7	7d Silicate facies, chert
F3	Oxide Iron Formation	Sediment	7	7a Iron formation

Queenston Legend			Final Queenston Legend for 3D Model and Surface Map	
GS	Carbonaceous/Graphitic Sediments	Sediment	7	7e Graphite facies
IF	Interflow material	Sediment	7	Chemical Metasedimentary Rocks
S1	Conglomerate	Sediment	8	8c Conglomerate
S2	Arkose	Sediment	8	Timiskaming-Type Clastic Metasedimentary Rocks
S3	Greywacke	Sediment	8	8b Wacke
S3B	Biotitic Greywacke	Sediment	8	8b Wacke
S4	Argillite/Mudstone	Sediment	8	8d Mudstone, siltstone
S6	Siltstone	Sediment	8	8d Mudstone, siltstone
header	VOLCANICS			
DF	Debris Flow	Volcanic	5	5d Breccia, pyroclastic breccia
FTH	Flow Top/Hyloclastite	Volcanic	2	2d Hyaloclastite, flow breccia
V13	Ultramafic Flow	Volcanic	1	1K Komatiite
V14	Basaltic Komatiite	Volcanic	1	1B Basaltic komatiite
V15	Ultramafic Komatiite	Volcanic	1	1K Komatiite
V2	Rhyolite/Dacite	Volcanic	4	Felsic (to Intermediate) Metavolcanic Rocks/Intrusions
V4	Trachyte	Volcanic	5	Alkalic and Subalkalic Metavolcanic Rocks/Intrusions (Unconformable Timiskaming Type) Alkalic Metavolcanic Rocks Intrusions
V4T	Trachytic Tuff	Volcanic	5	5c Tuff
V7	Basalt/Andesite	Volcanic	2	Mafic (to Intermediate) Metavolcanic Rocks/Intrusions
V7M	High Mag Basalt	Volcanic	2	2F High-iron tholeiite
V9	Tuff	Volcanic	5	5c Tuff
V9a	Tuff - ash	Volcanic	5	5c Tuff
V9L	Tuff lapilli	Volcanic	5	5c Tuff
V9x	Tuff - crystal	Volcanic	5	5c Tuff
VCIC	Volcaniclastic	Volcanic	8b	8b Wacke

Scope for Further Improvement

Owing to time constraints, the model produced is generalized. The carbonatized ultramafic could be broken down into individual lenses. Drill-hole logs are generalized; for a more detailed model, the original, more detailed, legend would be reverted to, allowing better delineation of rock types. The model follows the outcrop of the surface map reasonably well; it is not known if rock types were projected vertically to surface through the overburden.

With sufficient time a township-scale model could be developed incorporating Anoki, McBean and Upper Canada. This could be facilitated with further input from company drill logs and drill logs available from the Regional Geologist's Drill Core Library.

QUEENSTON MINING INC.: UPPER CANADA MINE

General Information

- Mine site location: Gauthier Township (see Ispolatov and Lafrance 2005)
- Deposit type: Archean lode gold
- Property owner: Queenston Mining Inc.
- Data donor(s): Queenston Mining Inc, Inco Ltd., Ontario Geological Survey (OGS)
- Model built by: P. Vasak, with assistance from C.A. Hawson, P. Geo., J. Whitmore, G. Wang, B. Anderson and G. Yang
- Checked by: D. Alexander, P.Geo. and C. Page, P.Geo., Queenston Mining Inc.

Background

The deposit is an Archean lode gold deposit located in Gauthier Township in the Kirkland Lake area. The deposit is owned by Queenston Mining Inc. It occurs within altered ultramafic rocks of the Tisdale assemblage and unconformably overlying metasedimentary rocks of the Timiskaming assemblage and related syenite sills and plutons. The disposition of the Timiskaming assemblage and related syenite intrusions is controlled by the Cadillac–Larder Lake deformation zone. The deposit has a combined measured and indicated resource of 1 899 973 tons at 6.9 g/ton (http://www.queenston.ca/projects/kirkland-production.html, accessed 2005; Figure 13) and production of 4 648 984 tons at 0.301 oz/ton between 1938 and 1971 (Meyer et al. 2004). The Upper Canada Mine produced 1.5 million ounces of gold from quartz vein zones hosted in trachytic volcanic and sedimentary rocks along the Upper Canada Break (http://www.queenston.ca/ projects/kirkland-review.html, 2005).

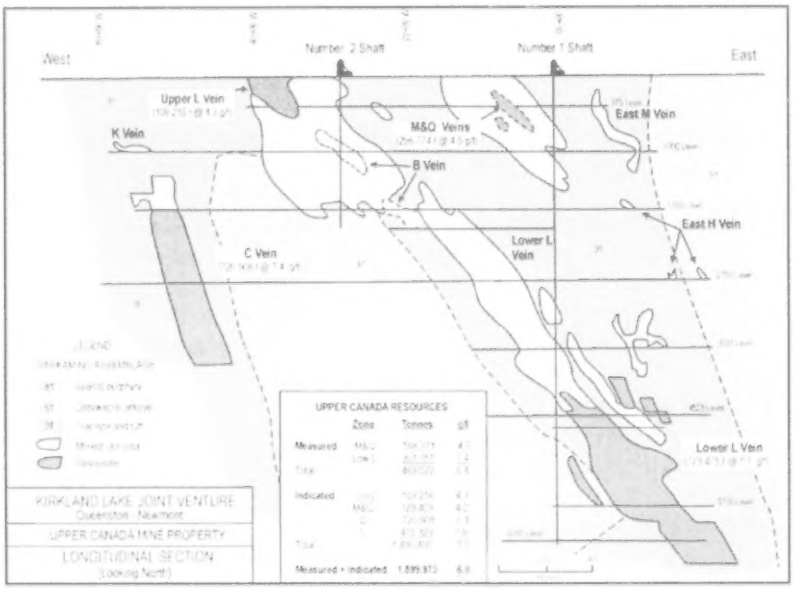

Figure 13. Ore resources of the Upper Canada Mine, from Queenston Mining Inc.'s website. (See chart in back pocket for colour version of this figure.)

Deposit Setting

Most of the ore at the Upper Canada Mine is along a subsidiary of the Larder Lake fault, in rocks of syenitic composition. Much of the Upper Canada ore is in quartz veins in silicified zones along the contacts of syenite porphyry, tuff, trachyte, and red trachyte porphyry (http://www.discoverabitibi.com/Kirkland%20Lake03.pdf 2005).

The Upper Canada deformation zone is the main structural feature. It consists of a system of branching and sub-parallel fractures, some gouge-filled and others vein-filled, predominantly with a dark cherty quartz. The fractures are found within a wide zone of schistosity developed 450 m on either side of the main "mud seam" (Byron 1994).

Intense carbonatization, sericitization, chloritization, pyritization and local silicification, together with the deformation, have destroyed most of the primary minerals and textural features within the deformation zone (Byron 1994).

The gold is associated with brecciated and mineralized veinlets of pale to dark bluish cherty quartz, except for the "B" zone, where the ore occurs in a fractured syenite porphyry (Byron 1994).

Data Donors and Sources

1. Queenston Mining Inc. provided on-site access to historical plans and sections. Scanning of the documents was done by BLAZE Information Technology Inc. (BLAZE I.T.). BLAZE I.T. was also contracted to do the vectorization of the scanned plans and provide the data in digital format as AutoCAD drawing files with geological contacts, structure and other related information saved to different drawing layers for later extraction and use.
2. Queenston Mining Inc. provided digital drill-hole data (73 surface exploration holes), which was supplemented by an additional 3 surface drill holes provided by Inco Ltd.
3. Inco Ltd. also donated 547 AutoCAD drawing files. These consisted of both plans and sections, and focused on the No.2 Shaft area (the Upper "L" and "B" veins; see Figure 13). Assay information (as text labels) in these files is based on the assumption that $/ton assays (based on $35.00/ounce) are equivalent to parts per million assays (D. Alexander, Queenston Mining Inc., personal communication, 2005).
4. All mine data was provided in the Upper Canada grid system.
5. Surface map information was provided by the Ontario Geological Survey (Ayer et al. 2004).
6. Supplemental surface geology was provided by MERC (Ispolatov and Lafrance 2005).
7. All surface map information was provided in digital form in NAD83, UTM Zone 17N grid coordinates.
8. The legend for the surface geology and the underground geology has been correlated with the regional-scale OGS legend used in Ayer et al. (2004).
9. Legend colours are derived from those used in Ayer et al. (2004).
10. Geographic data, Landsat imagery and geophysical maps were extracted from Ayer et al. (2004).

Modelling Procedure

1. A total of 60 Upper Canada Mine plans were scanned during the initial data collection trip to Queenston and saved as *.TIF graphics files. Of these, 39 plans were at 1 inch = 100 feet (100 scale) and 21 were at 1 inch = 20 feet (20 scale). An additional five 100 scale plans for the 375,

500, 625, 750 and 875-foot levels were scanned during a follow-up data collection trip. The images were reviewed and evaluated for their data content, with particular attention to the presence of interpreted structural features (faults, "breaks" and veins), lithological interpretation and alteration zone identification (colouring). Of these, 52 images (twenty 20 scale and thirty-two 100 scale) were vectorized by BLAZE I.T. (Figure 14), and data was saved in separate layers in AutoCAD drawing file format.

2. A total of 36 sections were acquired (one 100 scale and thirty-five 50 scale). Of these, 23 were vectorized by MIRARCO using ArcGIS and stored as shape files.
3. All vectorized lines from the scanned images were imported into gOcad. The lines were georeferenced to the Upper Canada grid.
4. The following objects were built from the vector data:
    a. Drift locations and, where practical, 3D drift surfaces were created, e.g., Nos.1 and 2 shafts.
    b. Alteration zones (the zones coloured by a pale yellow-green colour on the original plans and sections and identified as alteration zones by D. Alexander during the data collection phase).
    c. All faults and mineralized veins.
    d. Three lithological surfaces: the diabase dike defining the western extent of the model; the Syenite Porphyry (also termed the feldspar porphyry); and the Timiskaming-type clastic metasedimentary rock contact on the eastern end of the model.
5. Drill-hole data was extracted from the Excel spreadsheet provided by Queenston and collar, survey, assay and lithology files were constructed, since this format is required by both gOcad and FracSIS as input. Mine-specific lithological definitions were converted to Ayer et al.'s (2004) definitions and the accompanying colour map files were created.
6. Inco Ltd. provided a total of 547 AutoCAD drawing files, including both plans and sections, focusing on the No.2 Shaft area. All files were reviewed for data content, and non-duplicate files containing the most relevant structural, lithological and underground drill-hole information were further processed. Processing included quality checking of layer elevation (Z value, which was elevation for plans or Easting for sections). Where layer elevation was zero by default, the appropriate elevation was assigned. The AutoCAD drawings were imported in gOcad to Upper Canada Mine grid coordinates. This procedure included rotating the drawing axes for sections as follows: X = Northing, Y = elevation and Z = Easting.
7. From the Inco data the following objects were constructed:
    a. All underground drill-hole traces
    b. The Upper "L" and "B" vein stopes
    c. Mineralization envelopes were inferred from >1.0 ppm Au (or $1.00/ton at $35.00/ounce) markers on the drill-hole traces. It was impossible to reconstruct any true assay information from the AutoCAD drawings, however, the density of 1.0 ppm markers provided sufficient information to create isosurfaces of mineralization based on this cutoff value.
8. Due to gaps in the electronic data provided, the mineralization, stope surfaces and underground drill holes may be patchy, especially in the regions identified in Figure 15. Also, the lack of data below the 2900-foot level led to the decision to terminate the model at about this depth.

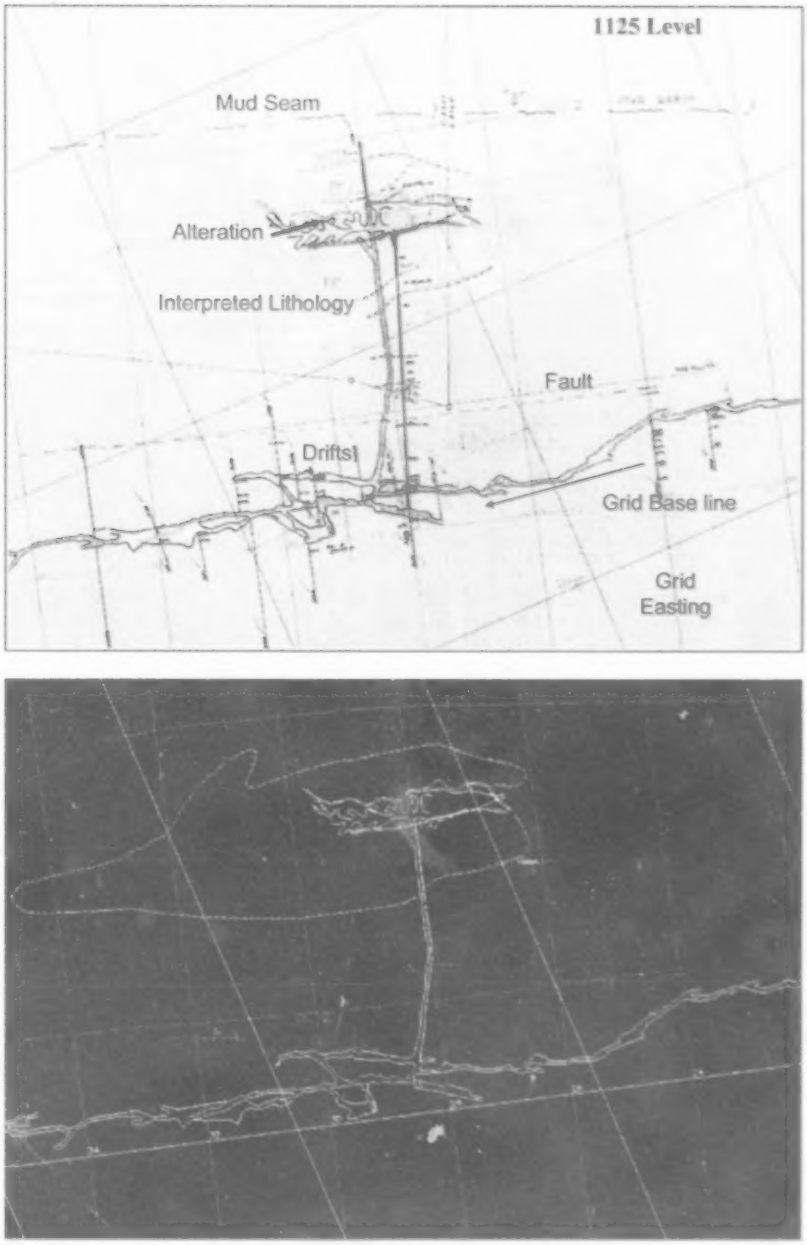

Figure 14. Example of scanned 1125 Level plan (top) and vectorized lines (bottom).

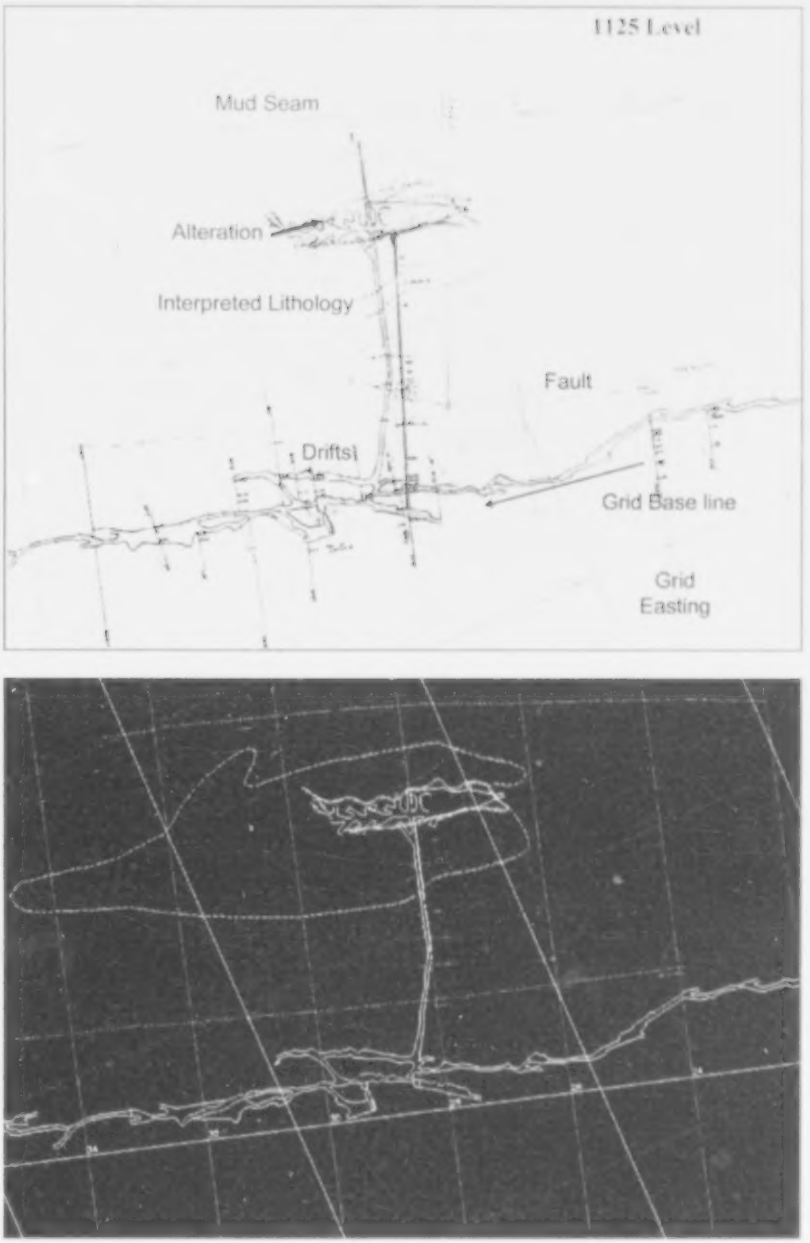

Figure 14. Example of scanned 1125 Level plan (top) and vectorized lines (bottom)

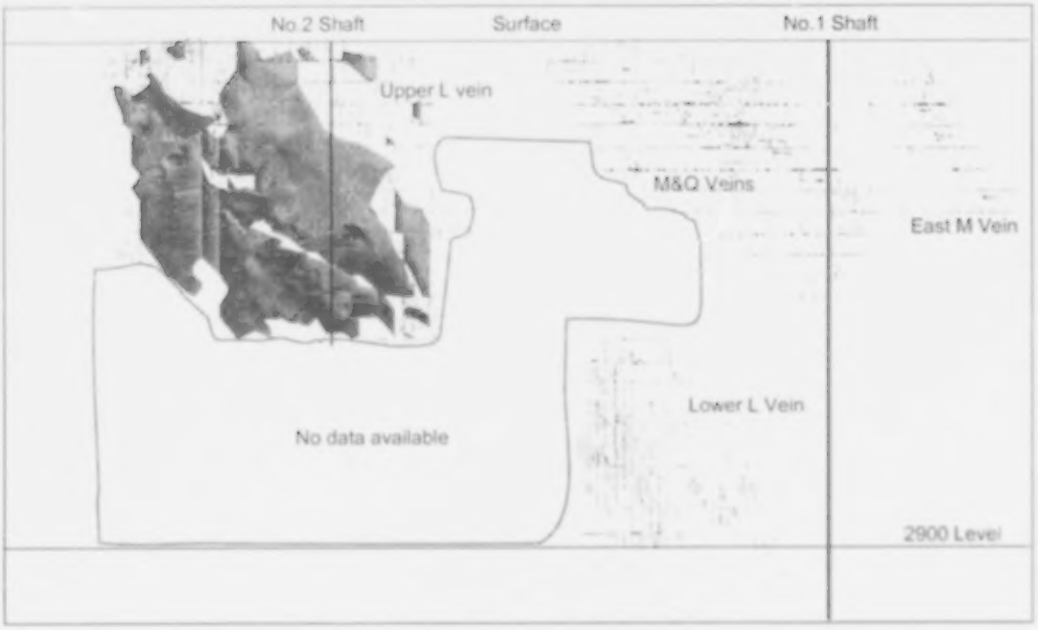

Figure 15. Cross section of the Upper Canada Mine showing the L, M and Q veins.

9. Data validation was done at each stage of the data transformation process:
    a. Scanned images were checked before archiving. Problem images were discarded and rescanned.
    b. Vectorized linework was compared to the original images and, where information was missing or improperly georeferenced, the vectorization was redone to a satisfactory standard. It is not practical to capture all linework since some was penciled in on the original drawings, some line type conventions were not consistent from image to image or over the historical life of the mine, and the quality of individual images varied.
    c. Final validation of all objects in the 3D model was carried out by D. Alexander, P.Geo.
10. All 3D data is in the Upper Canada (UC) grid coordinate system and is linked to the NAD83, UTM Zone 17N grid via the following No.1 Shaft transformation:
    a. 587547.18 Easting = -137 UC East
    b. 5332739.16 Northing = 388 UC North
    c. 304.8 m ASL = 10 000 feet UC elevation.
    d. Rotation = 15.58 degrees counterclockwise
11. Modelling process:
    a. All vectorized lines were segregated into 3 main categories, from which the main model components were built:
        i. The trace of structural features to build the faults, breaks and veins. The basis for creating fault planes is that at least 2 vectorized lines must be used to create the plane and in most cases 3 or more are used. Note that where only one line is captured (digitized), no fault plane is created, therefore some faults are "missed" simply due to lack of data. The main groups of structures that were built are:
            1. The Upper Canada Main ("M") Fault.

2. The series of "Mud Seams" to the north and south of the main fault.
3. Mineralized veins.
4. Local faults crosscutting the mineralized veins.
5. The "post-diabase" or "North Branch EW Fault" at the western end of the model.

ii. Lithological contacts to build the main lithologies (correlated to the OGS legend of Ayer et al. (2004) by C.A. Hawson, P.Geo.):
1. The diabase dikes (OGS rock code 15) at the western extent of the model.
2. The Syenite Porphyry (OGS rock code 11), which intrudes the alkalic and subalkalic metavolcanic rocks (not modelled, OGS rock code 5 on the surface maps) at the mine site.
3. The Timiskaming-Type Clastic Metasedimentary Rocks contact to the east (OGS rock code 8).

iii. Alteration zones as defined by the interpreted lines on the plans and sections (identified by the pale yellow-green colour). The two surfaces created in the model are most consistent with the description of the sericitized zones at the core of the shear zones. However, without definitive documentation, these zones may be broadly interpreted as the zones of intense carbonation, sericitization, chloritization and pyritization described by Byron (1994).

b. The 73 surface drill logs were correlated to the OGS legend of Ayer et al. (2004) by C.A. Hawson.

c. Stopes were created from sections.
i. Complete stopes for the Upper "L" and "B" veins were generated from the Inco sections.
ii. 50-foot stope ribbons were created elsewhere, since the section density was too poor to create a complete laterally continuous surface.

d. Inferred mineralization envelopes were created using the >1.0 ppm Au (see 7.c.) markers on the drill-hole traces. Whereas these surfaces may overestimate the extent of the actually mined ore, they do provide the locations of the mined veins, particularly away from the No.2 Shaft area where little or no stope information is present.

Scope for Further Improvement

The model is limited to about the 2900-foot level since the data digitized by Inco Ltd. only extends to this depth, however, there is a wealth of historical information for the entire mine. The lowest level that was scanned at the mine site is the 6150-foot level, however, reconstructing the lower part of the mine would require substantial resources to digitize paper plans, sections and logs. Particular emphasis should be placed on re-creating a digital database of the drill logs to reconstruct the mineralized zones from assay values and geological contacts, and alteration zones from the core descriptions.

The mine structural setting is highly complex and the current model only focuses on orientation and continuity of the faults at the mine scale due to time constraints imposed by the scope of the project. It was difficult to distinguish fault splays from cross cutting faults in the available data, particularly further away from the main fault where very little interpreted geology was available. Therefore, what appear to be fault splays in some instances may in fact be cross cutting faults (D. Alexander, Queenston Mining Inc., personal communication, 2005).

Summary and Conclusions

In this section we summarize points related to the development of 3D models and their relevance to Abitibi greenstone belt exploration at a regional scale, followed by discussion of important considerations flowing from development of the individual models.

GENERAL CONCLUSIONS

Computer-based 3D modelling in general is about 20 years old. Its application to mineral deposits is relatively new, with examples in the literature going back about 15 years (Chiles et al. 1992). Our experience in this project provides some important caveats for those considering embarking upon modelling. The 3D modelling process requires use of software capable of model production and visualization. These software systems are relatively robust and require substantial computing resources. In this project, we found that the minimum configuration for a computer engaged in the modelling was:

1) use of the Windows™ operating system (Windows 2000 Professional™; Windows XP Professional™);

2) a Pentium™ IV chip operating at a minimum of 1.5 Ghz;

3) at least 1 gigabyte of RAM and;

4) a 3D video card with at least 64 megabytes of RAM and open GL support.

For optimal performance:

1) Windows 2000 Professional or XP Professional operating system;

2) a Pentium IV chip operating at 3 Ghz;

3) 2 gigabytes of RAM;

4) a video card with 128 megabytes of RAM and dual monitor capable. The recommended video cards are NVidia GeForce™, NForce™ or Quadro™ series or ATI Radeon FireGL™ series card. The files for individual deposit models can be several hundred megabytes and, therefore, large storage resources are required (several tens of gigabytes).

The models produced in this project are somewhat generalized relative to those produced for the support of existing mining operations, for example, those of the Porcupine Joint Venture (Dome Mine, Pamour Mine, South Tisdale Anticline deposits). The level of detail in our models is constrained by the following factors, amongst others:

- Inconsistencies in the level of lithological and structural detail on mine plans and sections (*see* Figure 1).
- Inconsistencies in the level of detail and lithological and structural detail on drill logs produced during the exploration and production phases for individual properties.
- Variable scales of mine plans and sections and hence level of detail.

- Lack of operator-produced geological plans, sections or drill data. Information on some deposits such as Kirkland Minerals were not available, and the gap between Macassa and Teck-Hughes were handled by use of plans and sections from Thomson et al. (1948).

Our models are designed to support general understanding of the geometry and major controls on mineralization with respect to the deposits modelled. The most comprehensive models were produced where information from disparate sources has been pooled, such as company plans and sections, descriptions and diagrams from the journal literature, government maps and reports (e.g., Thomson et al. 1948) and last and most importantly—the fundamental data use to construct all of the above—logs of individual diamond-drill holes and surface maps of geological relationships.

The models produced in this project have in some instances (PJV deposits, Kirkland Lake Gold Inc. deposits, St Andrew Goldfields Ltd. and Queenston Mining Inc.) involved modelling of multiple deposits lying along strike from one another (Figure 16). The amalgamation of the models of the individual deposits provide an excellent transition to regional-scale models such as those produced by Géologie Québec (Fallara et al. 2004).

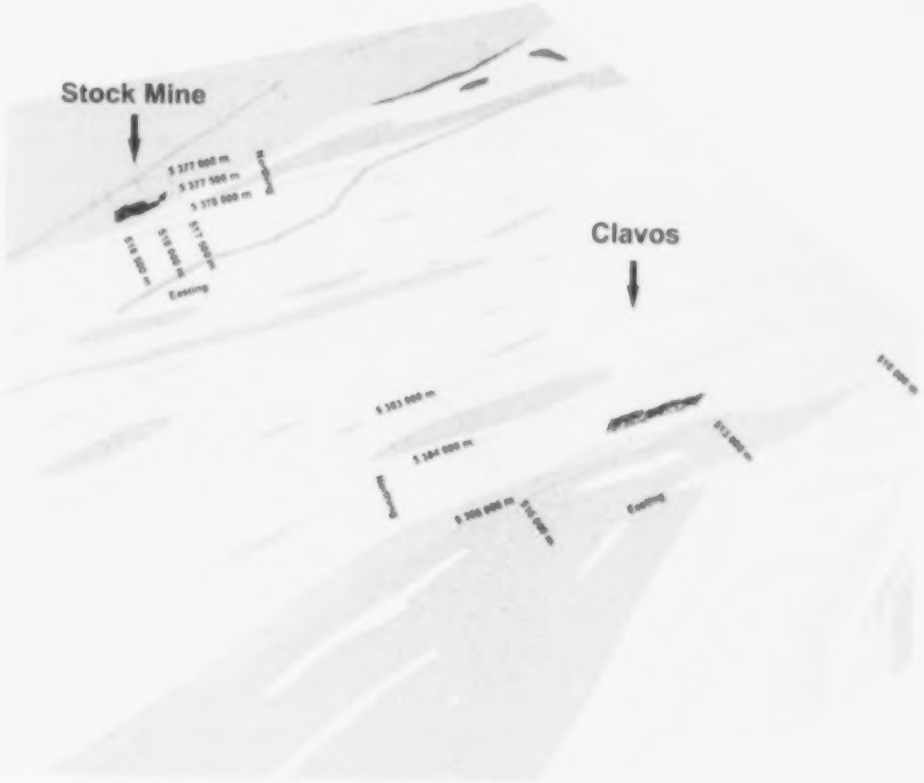

Figure 16. 3D amalgamation of the Stock and Clavos deposits of St Andrew Goldfields Ltd., showing regional and stratigraphic relationships. (See chart in back pocket for colour version of this figure.)

- Lack of operator-produced geological plans, sections or drill data. Information on some deposits such as Kirkland Minerals were not available, and the gap between Macassa and Teck-Hughes were handled by use of plans and sections from Thomson et al. (1948).

Our models are designed to support general understanding of the geometry and major controls on mineralization with respect to the deposits modelled. The most comprehensive models were produced where information from disparate sources has been pooled, such as company plans and sections, descriptions and diagrams from the journal literature, government maps and reports (e.g., Thomson et al. 1948) and last and most importantly—the fundamental data use to construct all of the above—logs of individual diamond-drill holes and surface maps of geological relationships.

The models produced in this project have in some instances (PJV deposits, Kirkland Lake Gold Inc. deposits, St Andrew Goldfields Ltd. and Queenston Mining Inc.) involved modelling of multiple deposits lying along strike from one another (Figure 16). The amalgamation of the models of the individual deposits provide an excellent transition to regional-scale models such as those produced by Géologie Québec (Fallara et al. 2004).

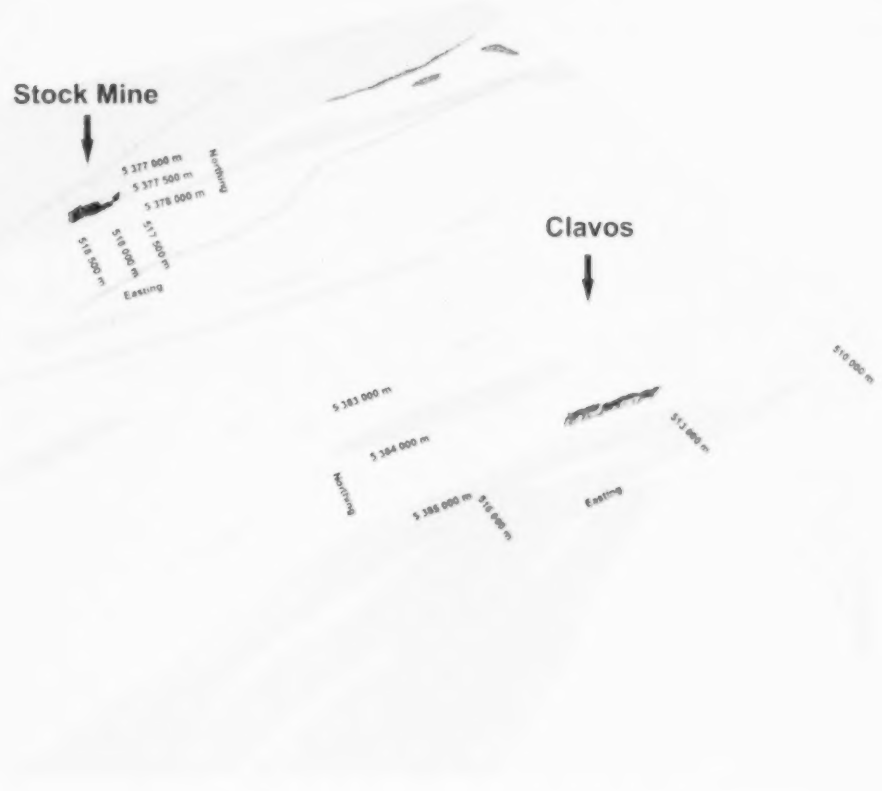

Figure 16. 3D amalgamation of the Stock and Clavos deposits of St Andrew Goldfields Ltd., showing regional and stratigraphic relationships. (See chart in back pocket for colour version of this figure.)

The level of detail in models produced from original material in this project is not sufficiently detailed to support resource modelling. Therefore, for many of the deposits described here, mineralization may have in the past been extracted at a profit, however, these "ore zones", "reserves" or "resources" are not compliant with definitions of these terms within National Instrument 43-101. Therefore, within this report the terms "mineralization" or "mineralized zone" have been used unless the mineralization as described is known to be compliant with NI 43-101.

Some detailed aspects of some of the individual deposits had to be disregarded in order to produce generalized high-level models of the mineralization. Our main example of this phenomenon is within the Lakeshore Mine, currently owned by Kirkland Lake Gold Inc., where there is an apparent shift in the strike of mineralized zones with increasing depth that could not be explained in the time available.

We have alluded earlier in this report to the variability in the quality and density of information present on various scales of mine plans. The fundamental, original data from which 3D models of mineral deposits are produced are diamond-drill logs and original maps of surface and underground geology. We have established that there are major fundamental problems with the drill records for many of the past and presently producing deposits. The problem relates directly to the non-systematic nature of drill records. For example, a single deposit contained over 1000 lithological descriptive terms, and gold assay values were expressed in a variety of units ranging from the classical pennyweight units to ounces/ton to grams/tonne to dollars/ton. Based on our experience, georeferencing and digitizing of original data should not be done by support staff. In our experience, the modeller develops a close and detailed knowledge of the deposit through performing these tasks, resulting in the production of a higher-quality model and, more importantly, this is the most efficient method. The quality of mineral deposit models is a direct function of the resources available both in terms of starting materials and in the amount of time put into the modelling process.

An additional element of importance is the issue of geochemical data. Regardless of the mineral deposit type, alteration haloes provide a larger footprint for detection of economic mineralization. The information provided for production of models did not include geochemical data. Addition of this type of data will enhance the use of the models in exploration, allowing the use, for example, of many of the very effective tools for analysis of geochemical data in exploration (e.g., Large et al. 2001).

As previously discussed, there were great problems with lack of consistency in drill records for many deposits, in large measure a function of the increasing sophistication of mapping over the lengthy production history of many of the deposits. The project required the integration of, for example, up to 17 000 drill holes with over 1000 lithological descriptive terms for a single deposit e.g., Kidd Creek (Falconbridge Ltd.) and Macassa (Kirkland Lake Gold Inc.). The level of effort required to simplify drill records was approximately equal to the time spent digitizing maps and plans or the amount of time spent actually modelling the deposits. The most effective tools for reduction of complexity in drill records involved compilation and sorting of drill records in Datamine. Note that in the course of this project we established that many of these drill datasets were beyond the capacity of Excel to simplify the data.

The project integrated deposit-scale geological units with the regional legend used by Ayer et al. (2004) to render the legends at the deposit scale consistent with regional-scale understanding. This integration of legends allowed detailed correlation of deposit-scale units with regional-scale units. It was thus possible to identify deposit-scale shear zones in lode gold deposits, and their relationship to regional-scale shear zones.

GEOLOGICAL CONCLUSIONS

Volcanogenic Massive Sulphide (VMS) Deposit Models

Two VMS deposit models are provided from this project: the model of the Kidd Creek Mine, donated by Falconbridge Ltd.; and the model of the Potter Mine of Millstream Mines Ltd., produced in this project. Both models portray a 3D model of the enclosing host stratigraphy and the mineralization. The stratiform, stratabound nature of the mineralization is clear in the models. However, neither model has geochemical data attached to allow modelling of the extent and character of the alteration halo surrounding the deposits. VMS models of the sort presented through this project are a valuable data source for regional mapping in which the character and geometry of host units can be integrated with regional-scale map patterns. In fact, the model of the Kidd Creek deposit is making a valuable contribution to understanding of the gravity and electromagnetic signature of a large VMS deposit (L. Reed, consulting geophysicist, personal communication, 2005). In an ideal world, one would combine the stratigraphic and lithologic patterns in the VMS models with lithogeochemistry to establish the spatial patterns of alteration associated with the deposits.

Lode Gold Deposit Models

The deposit-scale lode gold models produced in this project show a clear spatial association with the major strike-slip shear zones in the Abitibi greenstone belt (the Porcupine–Destor deformation zone and the Cadillac–Larder Lake deformation zone) and their related second- and third-order structures, as indicated in many reviews of this deposit type (e.g., Hodgson 1993). Some of the deposits modelled in this project (e.g., Holt-McDermott and Harker Holloway deposits, owned by Newmont Mining Inc.) occur on second-order shear zones but also have a clear association with lithological contacts (Lunnetra and Benn 2001) as well as a spatial association with iron-rich rock types such as iron tholeiites and komatiites. In the Kirkland Lake camp, in particular, many of the lode gold deposits occur along broadly east-trending shear zones cut by later north-trending post-ore faults. There is some indication of the remobilization of mineralization where the north-trending structures cut the east-trending shear zones. The D zone in the Macassa Mine of Kirkland Lake Gold Inc. is a north-trending mineralized zone from which we conclude that north-trending structures may represent a new style of gold mineralization in the Kirkland Lake camp.

An important caveat in reviewing the models produced here is that most of the initial data for the project was mine plans and drill records, with few sections available. Therefore, the models may have not included a number of mineralized structures with dips of <60°. Plans and sections for some of the gold deposits date to the early years of the Kirkland Lake gold camp. Thus, geological nomenclature is from that era and plans did not reveal much exploration drifting or drilling beyond the limits of the deposit. As much of the geological mapping is from the 1930s through to the 1960s, the donated information did not include data on the geochemistry of the host rocks. As well, given the limitations of gold analysis during the productive era, the project had no data on the extent of metasomatism connected with the mineralizing event. Modern geochemical studies of this sort are present in the literature (e.g., Fryer et al. 1979; Kerrich 1986). For a number of deposits, generalized sections from the report of Thomson et al. (1948) were the major source of sections, and thus the level of detail on sections was necessarily generalized.

SUCCESSES

The production of the models in this project involved review of draft versions of the models with the geological staff of the company that donated the data. This review by the geologists most familiar with the deposit revealed one of the real strengths of 3D modelling: improved 3D visualization resulted in company geologists identifying additional exploration targets in their own data. Examples of improved visualization of exploration data include:

- identification of a significant data gap between the Anoki and McBean deposits of Queenston Mining Inc.
- identification and visualization of relatively flat-dipping structures in the Macassa Mine of Kirkland Lake Gold Inc.
- identification and visualization of north-south-trending mineralization, related in part to post-ore faulting and possible reactivation of structures in the Macassa Mine.

FUTURE OF MODELLING IN THE ABITIBI

The models produced in this project were created in a period totalling less than 7 months. An attempt was made to produce complete models incorporating as much of the geological framework of the deposits as possible. There are gaps in the models which are a function of 2 parameters: the uneven nature of the geological data provided; and the lack of time and budget to do more elaborate modelling. We believe, however, that we have succeeded in providing within these models a three-dimensional representation of the major features controlling disposition of the mineralization.

Where appropriate and feasible, the three-dimensional models of multiple deposits have been amalgamated into unified models, such as the combination of the Teck-Hughes, Wright-Hargreaves and Lakeshore deposits. We also modelled Macassa and Kirkland Minerals as a unit (it was not possible to model the 5 Kirkland Lake Gold deposits as a unit because of the limitations of computing power and the immense size of the dataset involved). Queenston's Anoki and McBean properties were also modelled as a unit. This process of modelling increasingly larger areas points to the future potential to produce regional-scale 3D models. Obviously such models would be done on a less detailed scale than mineral deposit modelling, but great benefit can be derived by the exploration industry from the modelling of regional-scale structures and/or stratigraphic units. Regional-scale modelling is being done in Québec by the Ministère des resources naturelles et de la faune.

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Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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